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The comparative osteology of grebes (*Aves*: *Podicipediformes*) and its systematic implications

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Abstract. A total of 392 skeletons of grebes belonging to 20 taxa (16 species and 4 subspecies) were examined. Fifty-five osteological characters differentiating the species were found in all skeletal elements and several measurements of each bone were taken. To evaluate the relationship between the taxa examined, the measurements were subjected to a principal component analysis and cluster analysis, whereas the number of characters shared by two or more taxa was used for non-metrical comparisons. Sexual dimorphism in size of four taxa was studied in detail. The systematic position of all the genera of grebes is discussed and a revision of the genus *Podiceps* is proposed, to the effect that 1) the species *"Podiceps" major* is placed in a new monotypic genus *Podicephorus*, and 2) *Podiceps grisegena grisegena* and *P. grisegena holboellii* are restored to their species status.

Key words: *Podicipediformes*, osteology, taxonomy, *Podicephorus* gen. nov.

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I. INTRODUCTION

Although grebes belong to the groups of birds whose most species have been studied in detail (VLUG & FJELDSÅ 1990), there seem to be still some gaps in our knowledge – even that of the probably most thoroughly studied species, *Podiceps cristatus*. One of such gaps concerns the comparative osteology of grebes. The few papers dealing with this subject (e. g. BAMS 1956; SANDERS 1967; STORER 1963a; ZUSI & STORER 1969) can be used only to a limited extent in determination of fossil finds. As STORER (1992) has pointed out, the fossil species of grebes are badly in need of revision. Therefore, the comparative osteology of the family, including species from all the continents, would be a great help. Moreover, a detailed, comparative study of all the skeletal elements of grebes could provide additional anatomical evidence of their relationships and phylogeny. It could also help answer the questions regarding the evolutionary history of *P. grisegena* (i. e. whether it originated in North America or in Europe).

The two main purposes of this study were as follows: 1) to describe the osteological and mensural characters differentiating the European species of grebes and to compare the results with the extra-European species, and 2) to examine phenetic associations within the *Podicipedidae* via multivariate analyses, and, in conjunction with other published data, to propose some changes in the classification of this family.

The bulk part of the material was collected while I was holding a one-year scholarship from the Deutscher Akademischer Austauschdienst (DAAD) and was staying in Germany. Analyses were performed in an IBM computer supplied by the DAAD. If it had not been for their help I should not have been able to gather so much material and to analyze it. Special thanks are due to my tutor during my scholarship-tenure, Prof. Dr D. KRUSKA, and to the staff of the Institut für Haustierkunde der Christian-Albrechts-Universität at Kiel, who were always very helpful with both scientific and personal matters. I will always treasure the friendly atmosphere of the Institute in my memory.

I should not have been in a position to complete this work to the extent presented here without the kind and disinterested help of many persons with collecting the materials. I owe them all my most heartfelt gratitude. First of all my thanks go to the curators who helped me personally during my stay at their institutions, and whose help often exceeded their duty: Dr Z. BOEV (NNHM), Prof. Dr A. VON DEN DRIESCH (IPD), Dr J. FJELDSÅ (ZMC), Dr D. HEINRICH and Dr H. REICHSTEIN (both IH), Prof. Dr H. HOERSCHELMANN (ZMH), Dr E. N. KUROCHKIN (PI), Prof. Dr G. MAUERSBERGER and Prof. Dr B. STEPHAN (both MN), Dr H. PIEPER (ZMK, PIEP). I also extend my sincere thanks to the curators who responded to my request and lent me their materials, which must have been a time-consuming task: Dr I. BISHOP and Dr G. S. COWLES (both BMNH), Dr T. CASSIDY (TM), Dr J. DICK (ROM) Dr A. FORSTEN (ZIH), Dr D. HEIDECKE (IZ), Dr D. MÖRIKE (NM), Dr R. B. PAYNE (MZM), Dr O. POTAPOVA (ZIP), Dr G. RHEINWALD (MAK), Dr C. SPAW and Dr C. WOOD (both TBMM).

Dr J. GODAWA helped me with multivariate analyses and Dr Z. STEBNICKA and Prof. Dr M. MROCZKOWSKI with the taxonomic presentation of the results. My father, Prof. Dr Z. BOCHEŃSKI and my tutor Prof. Dr H. KUBIAK provided helpful comments on the manuscript of the paper.

II. MATERIAL

Analyses were based on 392 skeletal specimens representing 20 taxa (16 species and 4 subspecies) of grebes from all over the world. Since there are 20 – 21 species of grebes in the world (STORER 1979; VLUG & FJELDSÅ 1990), only four (five) of them are not included in this study. Four of them (*Tachybaptus rufolavatus*, *T. pelzelnii*, *Podilymbus gigas* and *Poliocephalus rufopectus*) are extremely rare in osteological collections (WOOD & SCHNELL 1986) and the fifth one (*Aechmophorus clarkii*) is sometimes considered to be a subspecies of *A. occidentalis* (e. g. STORER, 1979). Most of the specimens examined belong to five European species (*T. ruficollis*, *P. auritus*, *P. cristatus*, *P. g. grisegena* and *P. nigricollis*) and one to a North American taxon (*P. g. holboellii*). Some extra – European species, which are very rare and/or poorly-represented in osteological collections, are represented by single specimens only. Table I shows the total numbers of specimens of each species included in this paper. A few more specimens were examined but later they were excluded from the analyses since they were either not fully-ossified or probably wrongly determined.

The origin of the specimens examined is as follows: *Rollandia rolland* (QUOY & GAIMARD, 1824) – Argentina and Peru (one specimen belonged to *R. r. morrisoni* and four to *R. r. chilensis*, but all specimens were pooled); *Rollandia microptera* (GOULD, 1868) – Lake Titicaca, Peru; *Tachybaptus novaehollandiae* (STEPHENS, 1826) – Australia; *Tachybaptus ruficollis ruficollis* (PALLAS, 1764) – Europe; *Tachybaptus ruficollis capensis* (SALVADORI, 1884) – Azerbaijan and Republic of South Africa; *Tachybaptus dominicus* (LINNAEUS, 1766) – Cuba, Mexico, Guatemala; *Podilymbus podiceps* (LINNAEUS, 1758) – USA, Columbia, (i. e. pooled specimens of *P. p. podiceps* and *P. p. antarcticus*); *Poliocephalus poliocephalus* (JARDINE & SELBY, 1827) – Australia; "*Podiceps*" *major* (BODDAERT, 1783) – southernmost part of Argentina; *Podiceps auritus auritus* (LINNAEUS, 1758) – all specimens from Europe except one from Azerbaijan; *Podiceps auritus arcticus* BOJE, 1822 – Island, Faeroe Islands, N. Norway (distinction of *P. a. auritus* and *P. a. arcticus* after FJELDSÅ (1973a) on the basis of the collection locality and the season of the year); *Podiceps auritus coconuts* (GMELIN, 1789) – USA (excluded from PCA and cluster analyses); *Podiceps grisegena grisegena* (BODDAERT, 1783) – most specimens from Europe, some from W. Asia; *Podiceps grisegena holboellii* RHEINHARDT, 1854 – two specimens from the Far East, the others from N. America; *Podiceps cristatus* (LINNAEUS, 1758) – most specimens from Europe, some from Azerbaijan; *Podiceps nigricollis nigricollis* BREHM, 1831 – most specimens from Europe, some from Azerbaijan and Central Asia; *Podiceps nigricollis californicus* HEERMAN, 1854 – Southern USA; *Podiceps occipitalis occipitalis* GARNOT, 1826 – Santa Cruz, Argentina; *Podiceps taczanowskii* BERLEPSCH & STOLZMANN, 1894 – Lake Junin, Peru; *Podiceps gallardoi* RUMBOLL, 1974 – Argentina (according to their label, elements of postcranial skeleton belong "probably" (!) to *P. gallardoi*); *Aechmophorus occidentalis* (LAWRENCE, 1858) – Manitoba, California (i. e. the dark and light forms described by STORER & NUECHTERLEIN (1985) were pooled).

The acronyms of the skeletal collections from Table I are as follows: BMNH – British Museum Natural History, Tring, England; IH – Institut für Haustierkunde, Christian–Albrechts–Universität, Kiel, Germany; IPD – Institut für Palaeoanatomie, Domestikationsforschung und Geschichte der Tiermedizin der Universität München, Germany; ISEA – Institute of Systematics and Evolution of Animals, Polish Acad. Sci., Cracow, Poland; IZ

Table I

Specimens examined and their origin. Acronyms of collections are explained in text

Species	IH	IPD	TBMM	ZMC	ISEA	PI	BMNH	MN	MZM	ZMH	NNHM	ZIP	MAK	ZMK	NM	ROM	PIEP	IZ	TM	ZIH	Total
Rollandia rolland	–	–	–	3	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	5
Rollandia microptera	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2
Tachybaptus novaehollandiae	–	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2
Tachybaptus ruficollis	9	20	–	1	3	6	12	3	–	3	–	–	2	3	–	–	–	–	2	–	64
Tachybaptus dominicus	–	–	–	1	–	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	4
Podilymbus podiceps	–	–	–	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
Poliocephalus poliocephalus	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
"*Podiceps*" *major*	–	–	–	1	–	–	–	–	1	5	–	–	–	–	–	–	–	–	–	–	7
Podiceps auritus	2	1	–	11	4	1	6	–	1	–	–	1	–	1	–	–	–	2	–	–	31
Podiceps g. grisegena	31	6	-	1	6	5	–	2	–	–	3	2	1	1	1	–	–	–	–	–	59
Podiceps g. holboellii	–	–	41	–	–	2	–	–	1	–	–	–	–	–	–	4	–	–	–	–	48
Podiceps cristatus	45	18	–	1	15	8	6	8	–	1	4	3	2	–	1	–	–	–	–	–	112
Podiceps nigricollis	1	10	–	14	5	5	–	1	–	–	1	–	–	–	–	–	3	–	–	–	40
Podiceps occipitalis	–	–	–	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	3
Podiceps taczanowskii	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Podiceps gallardoi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	2
Aechmophorus occidentalis	–	–	–	1	2	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	5
Total	88	55	41	41	39	30	24	14	11	9	8	6	5	5	4	4	3	2	2	1	392

– Institut für Zoologie, Martin–Luther–Universität, Halle, Germany; MAK – Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany; MN – Museum für Naturkunde der Humboldt–Universität, Berlin, Germany; MZM – Museum of Zoology, University of Michigan, USA; NM – Naturkundemuseum, Stuttgart, Germany; NNHM – National Natural History Museum, Bulgarian Acad. Sci., Sofia, Bulgaria; PI – Paleontological Institute, Russian Acad. Sci., Moscow, Russia; PIEP – Dr PIEPER's private collection, Zoologisches Museum, Kiel, Germany; ROM – Royal Ontario Museum, Toronto, Canada; TBMM – Thomas Burke Memorial Museum, University of Washington, Seattle, USA; TM – Trasnvaal Museum, Pretoria, Republic of South Africa; ZIH – Zoological Institute, Helsinki, Finland; ZIP – Zoological Institute, Russian Acad. Sci., St. Petersburg, Russia; ZMC – Zoologisk Museum, Copenhagen, Denmark; ZMH – Zoologisches Museum, Universität Hamburg, Germany; ZMK – Zoologisches Museum, Kiel, Germany.

III. METHODS

A total of fifty-five morphological characters differentiating grebe species were found in all skeletal elements. A number of specimens of each species were checked for these characters. Only the characters which occured in at least 66% of all the specimens of one species were taken into consideration in the present paper. This limit was suggested by BOCHEŃSKI and TOMEK (in print). Each morphological character included in this paper is shown in a separate drawing depicting the distinguished states of the character. The characteristic places are marked with a thick line in the pictures. A list of all the species of grebes examined follows the description of the distinguished states of each character. Species occurring in Europe are at the top of the list, followed by the extra-European ones. The sequence of species is adopted after VLUG & FJELDSÅ (1990). The division of the material into European and extra-European species was made in order to help the researcher make use of the guide-book to determine fossil grebes. Only the subspecies of *P. grisegena* are presented separately, since the numbers of specimens of the other subspecies were very small and they did not show particular differences.

When determining a bone, it is always advisable to compare it with its counterparts in various species within the same size range. In other words, one should avoid relying exclusively on the drawings. Each drawing shows one character only (thick line); the remaining features represented in it must not be taken into account.

To avoid misunderstanding, all the scientific names of various parts of bones used in this paper are illustrated in separate drawings. In ambiguous cases, it is the drawing rather than the name that should be referred to.

The data following the name of each species include the percentages of specimens which show the given state, and the total number of specimens (e. g. A = 76%, N = 34 means that 76% out of the 34 specimens examined showed the "A" state. The remaining specimens of the species were either of the "B" or the intermediate "AB" state). When the number of specimens is lower than ten, the percentages are replaced by absolute numbers (e. g. A = 7 spec.). In the cases with more than two states distinguished, all of them are listed but the characteristic state is given first (e. g. *P. cristatus*: C = 76%, A = 3 spec., B = 1 spec., N = 41). Species that showed no characteristic states (i. e. states occurring in more than 66% of the specimens) are marked "uncharacteristic".

Bones were measured to the nearest 0.1 mm with dial calipers. The measurements included: the total length, width of the proximal and distal parts, width of the shaft and various other measurements, according to the type of bone. The way of taking the measurements of each bone is shown in separate drawings. Basic statistics (including minimum, maximum, arithmetic mean, standard deviation and coefficient of variation) are given in appropriate tables. In five cases (*Podiceps cristatus*, *P. grisegena grisegena*, *P. grisegena holboellii*, *Tachybaptus ruficollis* and partly in *P. nigricollis nigricollis*) the basic statistics are presented for each sex separately. Differences between the sexes were computed using Student's T-test; the statistically significant ones are marked with one or two asterisks – according to the level of significance (* $p \leq 0.05$, ** $p \leq 0.01$). In the case of the remaining species, sexes are not distinguished because there were too few specimens examined from each sex. If the number of specimens examined was very low (one to seven), the basic statistics are not given. Instead, the raw data are listed. Such a procedure seems better, especially for species extremely poorly represented in the world's skeletal collections.

The analysis of the osteological characters in respect of their application in the systematics of grebes was done as follows: A species-to-species comparison was made for each character described, and the total number of the characteristic states shared by each pair of species was counted. The species which shared more characters were considered to be more closely related to each other. Missing data for some species in some characters were treated like those which did not agree with a particular state. All characters were treated as equally important in the analysis.

One ordination procedure (principal component analysis) and a clustering one (cluster analysis) were performed to evaluate phenetic variation in the osteological characters. In both cases the size effect was eliminated by dividing each variable by the cube root of the "body size". Prior to all multivariate analyses, data were transformed to their natural logarithms. The "body size" was calculated for each specimen in a similar way to that proposed by HOERSCHELMANN (1966, 1971):

$$\text{"Body size"} = \left(\begin{array}{c}\text{length of}\\ \text{sternum}\\ \text{(sternum: b)}\end{array} + \begin{array}{c}\text{length of}\\ \text{pelvis}\\ \text{(pelvis: a)}\end{array}\right) \times \begin{array}{c}\text{width of}\\ \text{sternum}\\ \text{(sternum: c)}\end{array} \times \left(\begin{array}{c}\text{height of}\\ \text{crista sterni}\\ \text{(sternum: f)}\end{array} + \begin{array}{c}\text{length of}\\ \text{coracoideum}\\ \text{(coracoideum: a)}\end{array}\right)$$

where: names with letters under the elements of the formula refer to the appropriate measurements given in "Results". An advantage of the "body size" over the body weight consists in that the former parameter, unlike the latter, does not vary throughout the year.

For the purpose of a cluster analysis, fifteen taxa and forty-seven measurements were chosen so that each species was represented by at least two specimens. Males and females within species were pooled to increase the number of taxa which met the $n > 1$ criterion. Then, the 47 variables were subjected to discriminant analysis. Thirty-five of them showed the "F value" greater than two, and consequently only they were used for further analysis (the variables are listed in Table XIX showing character loadings from principal component analysis). The weighted pair-group method using arithmetic means (described as "WPGMA" by SNEATH and SOKAL 1973) was applied on the matrix of squared Mahalanobis distances between the taxa. This method (rather than the unweighted pair-group average method) should be used when the cluster sizes are greatly uneven (SNEATH and SOKAL 1973), which was the case in our situation.

A principal component analysis was performed on the same 35 variables used in the cluster analysis. Here, the n > 1 criterion was given up, which resulted in an increased number of taxa compared (18 instead of 15). At first the PCA was carried out separately for males and females but next, for the following three reasons, the sexes were pooled within species: 1) the differences between the results obtained for males and those for females were relatively small (especially in more numerous species) and so they may well have resulted from individual (rather than sexual) variation; 2) unsexed specimens could be used in the analysis, which reduced the influence of individual variation; 3) there would have been only nine taxa with specimens of both sexes, which would have made the analysis very problematic. Arithmetic means for all the specimens of each species were calculated for each of the 35 variables used. The principal component analysis was then performed on the character correlation matrix of arithmetic means. A minimum-spanning tree (SNEATH and SOKAL 1973) computed from the average taxonomic-distance matrix was superimposed on the three-dimensional diagrams from the principal component analysis to further elucidate relationships among the species.

All statistical analyses were performed using the StatSoft CSS: Statistica package and NTSYS-pc Numerical Taxonomy Analysis System.

IV. OSTEOLOGICAL AND MENSURAL CHARACTERS

1. CRANIUM

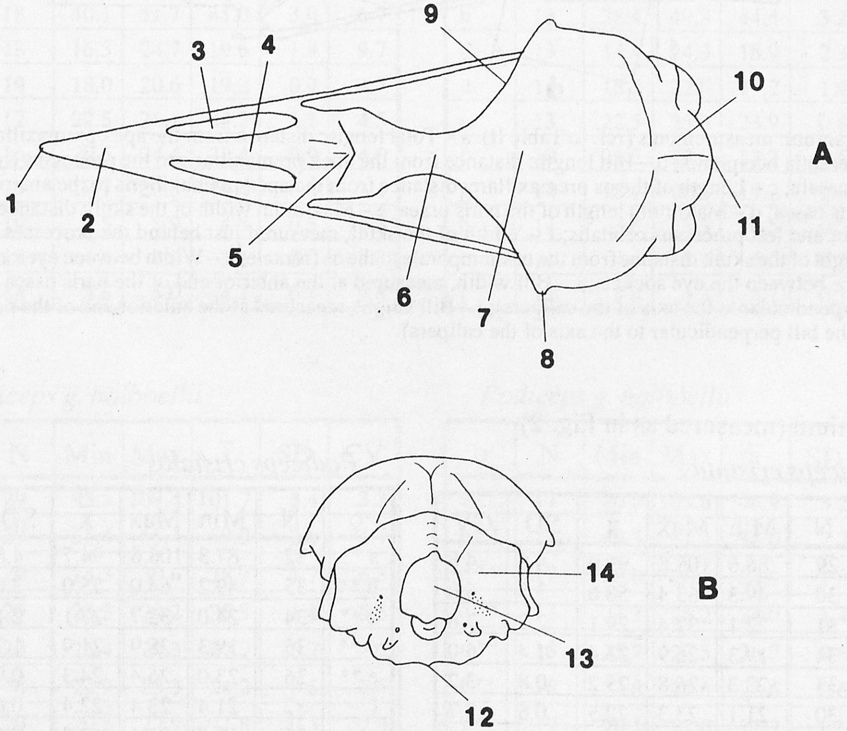

Fig. 1. Cranium: nomenclature. A - dorsal view; B - caudal view. 1 – Apex premaxillaris; 2 – Os premaxillare; 3 – Naris ossea; 4 – Os nasale; 5 – Processus frontalis of the os nasale; 6 – Pars nasalis of the os frontale; 7 – Os frontale; 8 – Processus orbitalis; 9 – Margo supraorbitalis; 10 – Os parietale; 11 – Protuberantia occipitalis; 12 – Basitemporale; 13 – Foramen occipitale magnum; 14 – Os occipitale.

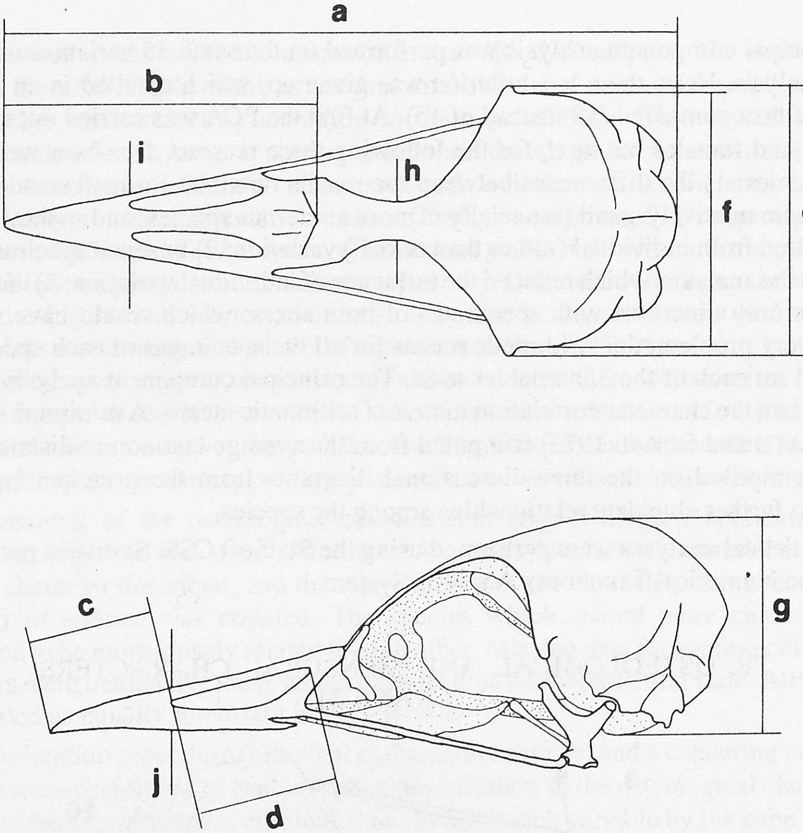

Fig. 2. Cranium: measurements (ref. to Table II). a – Total length: distance from the apex premaxillaris to the protuberantia occipitalis; b – Bill length: distance from the apex premaxillaris to the processus frontalis of the os nasale; c – Length of the os premaxillare: distance from the apex premaxillaris to the anterior end of the naris ossea; d – Maximum length of the naris ossea; e – Maximum width of the skull: distance between the right and left processus orbitalis; f – Width of the skull, measured just behind the processes orbitalis; g – Height of the skull: distance from the basitemporale to the os frontale; h – Width between eyes: narrowest distance between the eye sockets; i – Bill width, measured at the anterior end of the naris ossea (with the bill perpendicular to the axis of the calipers); j – Bill height, measured at the anterior end of the naris ossea (with the bill perpendicular to the axis of the calipers).

Table II

Cranium (measured as in Fig. 2)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	29	86.6	105.8	99.9	4.8	4.8
b **	30	49.3	63.4	58.6	3.5	6.0
c **	31	22.1	32.4	29.1	2.2	7.6
d **	34	19.3	26.9	23.4	1.4	6.0
e **	33	23.3	26.8	25.2	0.8	3.2
f	30	21.1	23.3	22.5	0.6	2.7
g	32	18.8	21.6	20.1	0.6	3.0
h **	32	3.9	5.9	5.0	0.4	8.0
i **	32	4.9	6.6	5.9	0.4	6.8
j **	33	3.8	5.0	4.5	0.2	4.4

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	32	87.3	106.6	94.7	4.8	5.1
b **	35	49.2	64.0	55.0	3.6	6.5
c **	34	24.0	32.7	27.1	2.1	7.7
d **	36	19.3	25.9	21.9	1.7	7.8
e **	36	23.0	26.4	24.3	0.9	3.7
f	32	21.4	23.4	22.4	0.6	2.7
g	36	18.7	21.4	19.9	0.6	3.0
h **	36	4.0	5.8	4.6	0.5	10.9
i **	36	4.6	6.5	5.6	0.4	7.1
j **	36	3.5	4.8	4.2	0.3	7.1

Table II cont.

Podiceps cristatus

?	N	Min	Max	x̄	SD	CV
a	20	88.4	103.8	96.8	5.2	5.4
b	20	49.6	62.5	57.0	3.7	6.5
c	21	22.4	31.5	27.2	2.5	9.2
d	23	20.6	25.5	22.9	1.4	6.1
e	23	23.5	26.4	24.7	0.8	3.2
f	13	21.3	23.6	22.4	0.7	3.1
g	23	19.3	21.2	20.1	0.4	2.0
h	23	4.1	5.7	4.9	0.4	8.2
i	20	4.7	6.3	5.7	0.4	7.0
j	20	3.8	5.9	4.4	0.4	9.1

Podiceps g. grisegena

♂	N	Min	Max	x̄	SD	CV
a **	13	82.0	87.9	85.7	1.5	1.8
b **	14	46.2	51.1	48.4	1.4	2.9
c *	14	19.2	22.8	21.0	1.1	5.2
d **	16	19.9	22.4	20.9	0.7	3.3
e *	15	23.5	25.9	24.9	0.6	2.4
f	15	21.5	23.5	22.6	0.6	2.7
g	15	18.3	20.8	19.7	0.6	3.0
h *	15	4.1	6.0	5.0	0.6	12.0
i	15	4.7	5.8	5.3	0.3	5.7
j **	15	3.9	4.7	4.3	0.2	4.7

Podiceps g. grisegena

♀	N	Min	Max	x̄	SD	CV
a **	18	74.2	91.5	81.1	4.4	5.4
b **	18	40.1	51.7	45.0	3.0	6.7
c *	18	16.5	24.7	19.6	1.9	9.7
d **	19	18.0	20.6	19.2	0.9	4.7
e *	17	22.5	26.1	24.2	1.1	4.5
f	16	20.6	24.4	22.4	0.9	4.0
g	19	18.7	20.5	19.4	0.6	3.1
h *	19	3.5	5.9	4.5	0.5	11.1
i	18	4.4	6.0	5.1	0.4	7.8
j **	18	3.6	5.0	4.1	0.4	9.8

Podiceps g. grisegena

?	N	Min	Max	x̄	SD	CV
a	13	71.6	89.3	80.5	4.5	5.6
b	13	38.4	49.8	44.4	3.2	7.2
c	13	14.4	24.3	18.9	2.3	12.2
d	14	18.2	22.0	19.7	1.4	7.1
e	13	22.5	25.3	23.9	0.8	3.3
f	10	21.2	23.0	22.3	0.5	2.2
g	14	18.1	20.3	19.2	0.6	3.1
h	14	3.6	5.3	4.5	0.5	11.1
i	11	4.6	5.3	5.0	0.2	4.0
j	11	3.8	4.3	4.1	0.1	2.4

Podiceps g. holboellii

♂	N	Min	Max	x̄	SD	CV
a **	29	95.5	109.4	101.7	3.4	3.3
b **	29	55.4	65.4	59.8	2.8	4.7
c **	29	24.3	30.6	26.9	1.7	6.3
d **	29	23.3	29.2	25.3	1.4	5.5
e **	28	26.4	29.3	27.7	0.7	2.5
f **	28	22.9	25.3	24.2	0.6	2.5
g **	29	20.5	22.9	21.8	0.5	2.3
h **	29	4.6	6.8	5.7	0.5	8.8
i **	27	5.2	6.5	5.7	0.4	7.0
j **	27	4.6	5.6	5.1	0.3	5.9

Podiceps g. holboellii

♀	N	Min	Max	x̄	SD	CV
a **	17	90.5	103.6	96.9	3.2	3.3
b **	17	49.5	61.2	56.0	2.7	4.8
c **	17	20.8	28.2	24.9	1.8	7.2
d **	17	21.7	26.2	24.0	1.4	5.8
e **	16	25.7	27.5	26.7	0.6	2.2
f **	16	22.8	24.6	23.6	0.6	2.5
g **	17	20.1	22.0	21.2	0.6	2.8
h **	17	3.9	6.1	5.3	0.5	9.4
i **	17	4.8	6.1	5.3	0.3	5.7
j **	17	4.2	5.1	4.7	0.3	6.4

Table II cont.

Podiceps g. holboellii cont.

?	Measurements	
a	98.7	99.0
b	57.9	57.9
c	25.5	26.0
d	24.0	24.8
e	26.4	26.8
f	–	
g	20.5	20.5
h	4.1	5.7
i	5.6	
j	4.7	

Podiceps a. auritus (7 ?, 1 ♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	8	54.8	62.6	59.0	2.8	4.7
b	8	27.0	31.0	28.9	1.6	5.5
c	8	9.3	11.7	10.6	0.9	8.5
d	8	12.9	15.3	13.9	0.8	5.8
e	7	20.0	21.6	20.7	0.7	3.4
f	6	19.2	20.6	19.8	0.5	2.5
g	8	16.0	17.7	16.7	0.7	4.2
h	8	2.6	3.2	3.0	0.2	6.7
i	7	3.4	4.4	3.9	0.4	10.3
j	7	2.4	3.2	2.8	0.3	10.7

Podiceps a. arcticus (4 ♂♂, 3 ♀♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	4	60.8	65.7	63.4	2.4	3.8
b	4	29.6	33.6	31.4	1.8	5.7
c	4	11.0	13.3	12.0	1.0	8.3
d	5	12.8	15.9	14.6	1.2	8.2
e	7	20.7	22.4	21.7	0.6	2.8
f	4	19.3	21.1	20.0	0.8	4.0
g	7	17.0	18.4	17.7	0.4	2.3
h	7	2.8	4.0	3.5	0.5	14.3
i	4	4.5	5.1	4.6	0.3	6.5
j	4	3.1	3.4	3.2	0.1	3.1

Podiceps auritus (*auritus* or *arcticus*; 2 ?, 1 ♀)

	Measurements		
a	57.4	59.3	59.5
b	27.5	28.6	29.1
c	10.3	10.8	11.6
d	13.5	13.5	13.7
e	20.1	20.5	20.6
f	19.0	19.5	
g	16.2	16.6	16.8
h	2.9	3.1	3.8
i	3.5	3.9	4.3
j	2.4	2.6	2.9

Podiceps a. cornutus (1 ♂)

	Measurements
a	60.9
b	29.5
c	10.5
d	14.7
e	20.6
f	–
g	16.2
h	3.2
i	4.0
j	2.9

Podiceps n. nigricollis (11 ?, 2 ♂♂, 1 ♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	7	49.8	57.1	54.8	2.3	4.2
b	8	23.6	29.3	27.3	1.7	6.2
c	11	10.3	12.6	11.5	0.9	7.8
d	12	9.5	13.0	11.7	1.0	8.5
e	12	17.7	19.2	18.4	0.5	2.7
f	9	17.5	18.6	18.0	0.4	2.2
g	12	15.2	16.4	15.7	0.4	2.5
h	13	2.2	3.1	2.7	0.3	11.1
i	10	4.5	5.0	4.7	0.2	4.3
j	10	1.9	2.5	2.2	0.2	9.1

Table II cont.

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	57.9	57.9	59.4	60.0
b	29.3	30.1	31.0	32.3
c	12.4	13.4	13.8	14.0
d	12.9	13.0	13.2	13.7
e	17.8	18.6	19.1	19.5
f	17.4	18.2	18.3	18.6
g	14.9	15.0	15.4	15.5
h	2.6	2.7	2.7	2.7
i	4.6	4.6	4.6	4.7
j	1.9	2.0	2.2	2.3

Tachybaptus r. ruficollis

♂	N	Min	Max	x̄	SD	CV
a	10	46.0	53.0	50.0	1.8	3.6
b	10	21.7	26.0	23.9	1.3	5.4
c *	10	6.9	9.1	8.2	0.6	7.3
d	10	9.6	12.8	11.6	1.0	8.6
e *	10	17.7	19.0	18.2	0.5	2.7
f *	7	16.9	18.1	17.5	0.4	2.3
g	9	14.4	16.1	15.2	0.6	3.9
h *	10	2.8	3.7	3.1	0.3	9.7
i	10	3.5	4.2	3.7	0.2	5.4
j	10	2.5	2.9	2.7	0.1	3.7

Tachybaptus r. ruficollis

♀	N	Min	Max	x̄	SD	CV
a	13	46.2	50.6	48.4	1.5	3.1
b	14	20.7	24.9	22.6	1.3	5.8
c *	15	7.0	8.8	7.7	0.5	6.5
d	16	9.7	12.7	10.9	0.9	8.3
e *	14	17.1	19.1	17.7	0.5	2.8
f *	13	16.7	18.3	17.2	0.4	2.3
g	14	14.4	15.6	15.2	0.4	2.6
h *	15	2.0	3.2	2.7	0.4	14.8
i	15	3.4	4.2	3.6	0.2	5.6
j	15	2.2	3.1	2.5	0.3	12.0

Tachybaptus r. ruficollis

?	N	Min	Max	x̄	SD	CV
a	21	44.4	51.8	48.2	2.3	4.8
b	21	19.9	25.0	22.4	1.7	7.6
c	21	6.2	9.0	7.6	0.9	11.8
d	22	9.6	12.3	10.9	0.8	7.3
e	23	16.9	18.5	17.7	0.5	2.8
f	19	16.5	18.1	17.2	0.5	2.9
g	22	14.7	16.1	15.4	0.3	1.9
h	23	2.3	3.6	2.9	0.4	13.8
i	23	3.3	4.1	3.7	0.2	5.4
j	23	2.0	2.8	2.5	0.2	8.0

Tachybaptus r. capensis (5 ?, 1 ♂)

	Measurements					
a	45.9	50.5	52.1			
b	21.8	22.8	23.0	23.1	23.7	25.0
c	7.7	7.8	8.1	8.3	8.4	9.7
d	10.6	10.6	10.8	10.9	11.3	11.7
e	16.8	18.2	18.7	18.9		
f	–					
g	14.5	14.9	15.5	16.2		
h	2.7	2.9	3.1	3.6		
i	3.4	3.4				
j	2.5	2.8				

Rollandia rolland (2 ♂♂, 2 ♀♀, 1 ?)

	Measurements				
a	45.7	49.6	51.3	56.3	
b	20.0	22.8	24.0	27.7	
c	7.8	8.7	9.7	10.9	
d	8.2	10.1	10.4	12.4	
e	17.9	18.9	19.2	19.3	
f	17.2	18.7			
g	15.4	15.9	16.2	16.3	16.7
h	3.0	3.5	3.6	4.4	4.5
i	3.7	3.8	4.1	4.2	
j	2.4	2.6	2.8	3.1	

Table II cont.

*Rollandia micropter*a (1 ♂, 1 ?)

	Measurements	
a	74.3	78.9
b	38.0	42.0
c	15.7	16.1
d	17.4	20.1
e	23.6	24.7
f	20.6	
g	18.8	19.8
h	4.7	5.7
i	6.1	6.4
j	3.6	3.8

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	47.9	50.5
b	23.1	24.4
c	9.0	9.1
d	10.3	10.7
e	17.9	18.1
f	17.2	
g	14.5	15.3
h	3.0	4.2
i	4.3	4.6
j	2.6	3.1

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	42.7	45.5	49.9	54.8
b	19.2	22.2	24.0	29.2
c	7.1	8.2	10.3	
d	8.8	9.5	10.1	
e	16.0	17.4	18.2	18.4
f	15.7			
g	13.7	14.3	15.0	15.1
h	3.0	3.0	3.4	4.2
i	3.7	3.7	4.2	
j	2.4	2.7	3.0	

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	53.1	53.9	60.2	62.2
b	22.8	23.3	27.0	27.7
c	9.0	10.4	10.5	
d	10.4	10.6	13.2	
e	18.9	19.4	20.4	20.5
f	19.3	20.3	20.4	
g	17.5	17.6	18.4	19.0
h	3.4	3.8	4.2	4.7
i	4.0	4.2	4.9	
j	4.1	4.2	4.8	

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	51.5	53.9
b	23.9	26.1
c	8.4	9.5
d	11.6	12.8
e	18.2	18.4
f	17.9	
g	15.5	17.1
h	3.2	3.3
i	3.7	3.8
j	2.8	2.8

"*Podiceps*" *major* (3 ?, 2 ♂♂, 2 ♀♀)

	Measurements						
a	111.4	112.9	116.5	116.5	122.1	123.9	126.2
b	69.2	70.2	72.5	74.0	75.2	80.3	80.5
c	44.5	44.7	44.8	46.7	46.9	50.7	51.7
d	19.1	19.1	19.8	21.0	21.8	21.9	22.9
e	23.0	23.5	24.4	24.5	24.8	25.5	25.9
f	21.5	21.9	22.1	22.3	22.5	23.1	
g	20.5	20.5	21.2	21.5	21.9	22.3	22.4
h	5.0	5.2	5.4	5.6	5.7	5.8	5.9
i	6.9	7.0	7.0	7.3	7.4	7.5	7.8
j	5.1	5.2	5.3	5.5	5.6	5.9	6.2

Podiceps occipitalis (2 ♂♂)

	Measurements	
a	48.6	52.6
b	22.1	24.9
c	8.7	9.4
d	10.6	11.8
e	18.4	18.5
f	18.2	
g	15.9	16.5
h	2.8	2.9
i	4.7	
j	2.0	

Table II cont.

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	–
b	34.4
c	14.9
d	15.0
e	–
f	–
g	17.4
h	4.1
i	5.5
j	2.8

Podiceps gallardoi (1 ?)

	Measurements
a	54.2
b	23.9
c	6.6
d	13.2
e	19.9
f	18.9
g	16.5
h	2.3
i	5.6
j	2.2

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀, 1 ?)

	Measurements
a	103.2 115.9 116.6
b	62.2 69.8 70.2
c	40.5 44.2 44.7
d	15.3 17.0 17.8 18.0 18.3
e	21.9 23.8 24.0 24.2 24.8
f	20.4 20.4 21.0
g	19.1 19.2 19.9 20.2 20.2
h	4.3 4.6 5.0 5.1 5.2
i	5.1 5.7 6.4 6.7
j	3.8 4.0 4.7 4.9

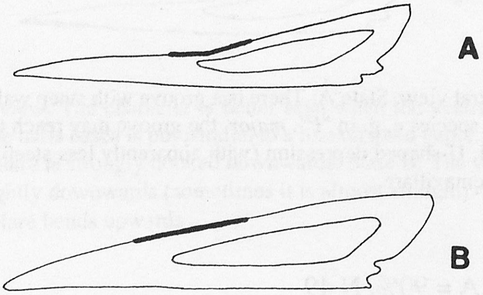

Fig. 3. Cranium 1: bill, lateral view. State A: The os premaxillare bends slightly upwards, which is especially well-seen at the beginning of the naris ossea. State B: The os premaxillare does not bend upwards. The joint between the os premaxillare and the os nasale is approximately straight.

Podiceps cristatus: B = 100%, N = 46
P. g. grisegena: B = 100%, N = 35
P. g. holboellii: B = 100%, N = 30
P. auritus: B = 100%, N = 12
P. nigricollis: A = 88%, N = 16
Tachybaptus ruficollis: B = 100%, N = 29

Rollandia rolland: B = 4 spec., N = 4
R. micropterа: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 7
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: uncharacteristic, N = 4

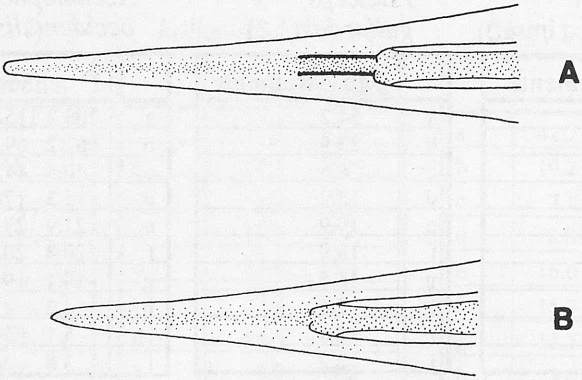

Fig. 4. Cranium 2: bill, ventral view. State A: There is a groove with steep walls in the posterior part of the os premaxillare (in some species e. g. in "*P*". *major*, the groove may reach the apex premaxillaris). State B: There is a long, broad, U-shaped depression (with apparently less steep walls than in state A) in the posterior part of the os premaxillare.

Podiceps cristatus: A = 90%, N 49
P. g. grisegena: B = 80%, N = 35
P. g. holboellii: uncharacteristic, N = 29
P. auritus: B = 100%, N = 15
P. nigricollis: B = 100%, N = 15
Tachybaptus ruficollis: B = 97%, N = 29

Rollandia rolland: B = 3 spec., N = 4
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 2 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: A = 7 spec., N = 7
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: A = 4 spec., N = 4

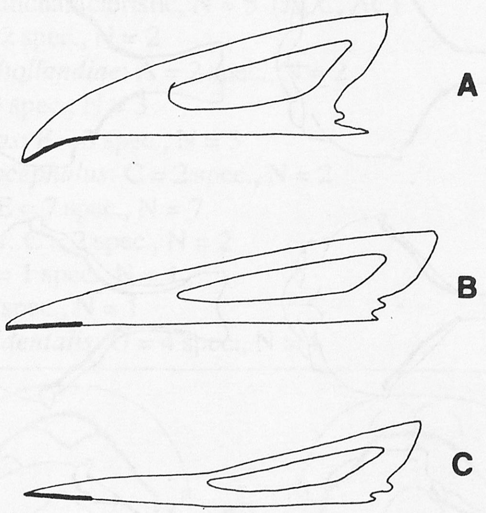

Fig. 5. Skull 3: bill, lateral view. The character is better seen when the ventral edge of the part of the os premaxillare just below the naris ossea is put parallel to a line on lined paper. State A: The ventral edge of the end of the os premaxillare is strongly hooked downwards. State B: The ventral edge of the end of the os premaxillare bends slightly downwards (sometimes it is almost straight). State C: The ventral edge of the end of the os premaxillare bends upwards.

Podiceps cristatus: B = 97%, C = 1 spec., N = 38
P. g. grisegena: B = 90%, C = 3 spec., N = 30
P. g. holboellii: B = 97%, C = 1 spec., N = 29
P. auritus: B = 100%, N = 11
P. nigricollis: C = 86%, N = 14
Tachybaptus ruficollis: B = 100%, N = 24

Rollandia rolland: B = 4 spec., N = 4
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: C = 6 spec., B = 1 spec., N = 7
Podiceps occipitalis: C = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: C = 4 spec., N = 4

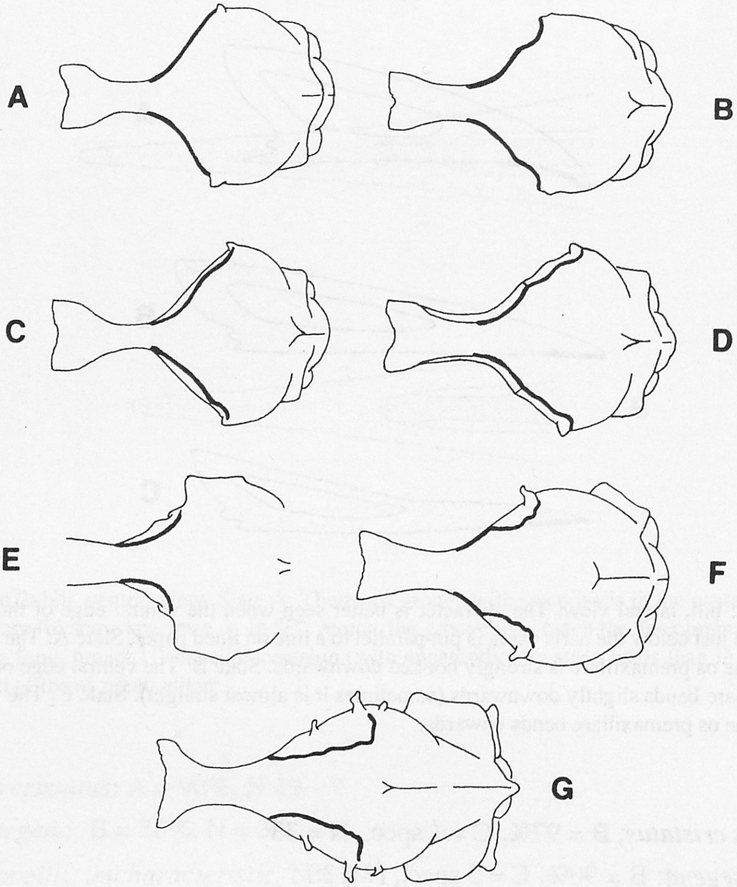

Fig. 6. Cranium 4: dorsal view. State A: A faint line follows the margo supraorbitalis (from the pars nasalis of the os frontale to the processus orbitalis). The line curves slightly but it is not wavy. The processus orbitalis is thin. State B: A faint, slightly curved line follows the margo supraorbitalis from the pars nasalis of the os frontale to the processus orbitalis. The line curves sharply just before the processus orbitalis. The processus orbitalis is wide. State C: A faint line runs approximately parallel to the margo supraorbitalis (from the pars nasalis of the os frontale to the processus orbitalis). The processus orbitalis is thin. State D: A very distinct, wavy, irregular line runs through the os frontale (from its pars nasalis to the processus orbitalis). The line is not parallel to the margo supraorbitalis. At one-quarter to one-third of its length, there is a crest linking the line and the margo supraorbitalis. The processus orbitalis is thin. State E: A faint (sometimes very faint), curved line runs through the os frontale (from its pars nasalis to the processus orbitalis). The processus orbitalis is very wide. State F: A faint line follows the margo supraorbitalis from the pars nasalis of the os frontale to the processus orbitalis. Half-way to the processus, the line curves through the os frontale. State G: A distinct line runs through the os frontale from its pars nasalis towards the back of the skull, then it turns (approximately at right angles) towards the processus orbitalis. The processus orbitalis is thin.

Podiceps cristatus: D = 100%, N = 46
P. g. grisegena: D = 100%, N = 20
P. g. holboellii: D = 100%, N = 30
P. auritus: C = 100%, N = 17
P. nigricollis: C = 100%, N = 14
Tachybaptus ruficollis: A = 92%, AC = 2 spec., N = 26

Rollandia rolland: uncharacteristic, N = 5 (A, C, AC)
R. microptera: C = 2 spec., N = 2
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: F = 3 spec., N = 3
Poliocephalus poliocephalus: C = 2 spec., N = 2
"*Podiceps*" *major*: E = 7 spec., N = 7
Podiceps occipitalis: C = 2 spec., N = 2
P. taczanowskii: C = 1 spec., N = 1
P. gallardoi: A = 1 spec., N = 1
Aechmophorus occidentalis: G = 4 spec., N = 4

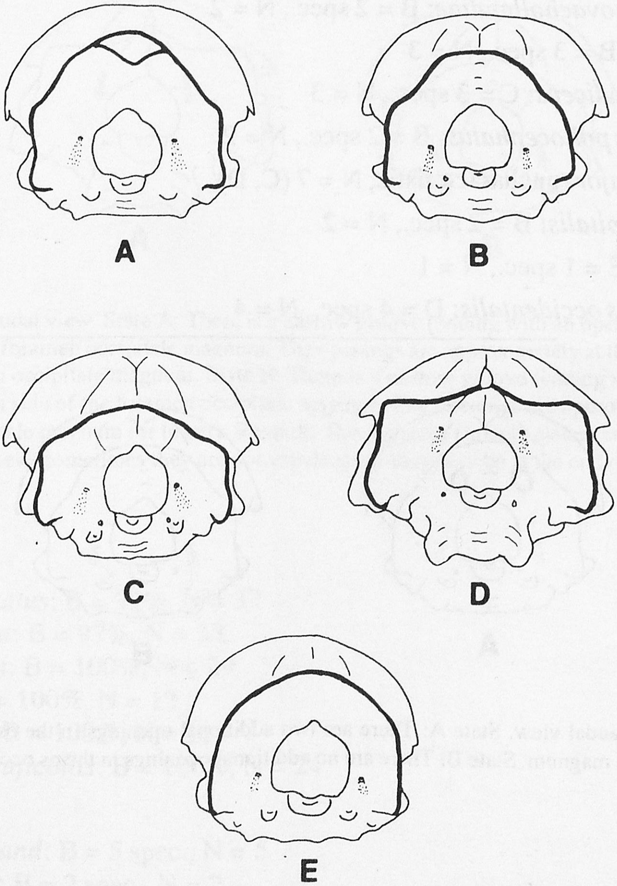

Fig. 7. Cranium 5: caudal view. State A: The edge of the os occipitale is in the shape of a high arch (It is approximately as high as wide or higher). The arch top is often formed by two lines: the upper and the lower (the upper line may be only just visible). On both sides of the arch, there are small (much smaller than the height of the arch) "ears", hard to distinguish. State B: The edge of the os occipitale forms a wide arch (wider than high). The top of the arch is broad and flat. On both sides of the arch, there are small (much smaller than the height of the arch) but distinct "ears". State C: The edge of the os occipitale forms a very wide arch (distinctly wider than high – wider than in state B). The top of the arch is broad and flat. On both sides of the arch there are big (but smaller than the height of the arch) and usually distinct "ears". State D: The edge of the os occipitale is rectangular. On its upper side, above the foramen occipitale magnum, there is a small peak. State E: The edge of the os occipitale is in the shape of a wide arch (wider than high). The top of the arch is broad and flat. Both sides of the arch are vertical and high (there are no "ears" there).

Podiceps cristatus: C = 100%, N = 46
P. g. grisegena: C = 97%, B = 1 spec., N = 35
P. g. holboellii: C = 97%, CD = 1 spec., N = 30
P. auritus: B = 100%, N = 16
P. nigricollis: A = 85%, B = 1spec., AB = 1 spec., N = 13
Tachybaptus ruficollis: B = 100%, N = 29

Rollandia rolland: B = 5 spec., N = 5
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: C = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 7 (C, D)
Podiceps occipitalis: B = 2 spec., N = 2
P. gallardoi: E = 1 spec., N = 1
Aechmophorus occidentalis: D = 4 spec., N = 4

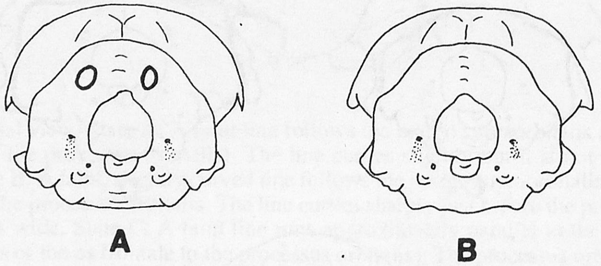

Fig. 8. Cranium 6: caudal view. State A: There are two additional openings in the os occipitale above the foramen occipitale magnum. State B: There are no additional openings in the os occipitale.

Podiceps cristatus: B = 91%, N = 35
P. g. grisegena: B = 73%, N = 33
P. g. holboellii: B = 100%, N = 29
P. auritus: B = 100%, N = 13
P. nigricollis: B = 100%, N = 12
Tachybaptus ruficollis: B = 96%, N = 24

Rollandia rolland: A = 5 spec., N = 5
R. microptera: A = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 2 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 5 spec., N = 7
Podiceps occipitalis: B = 2 spec., N = 2
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: B = 4 spec., N = 4

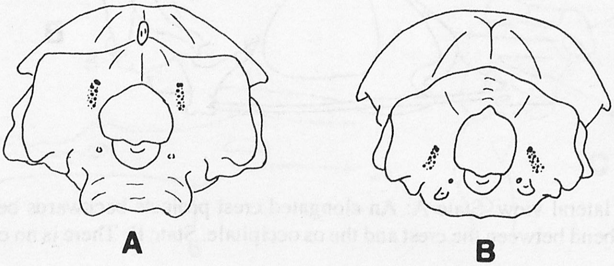

Fig. 9. Cranium 7: caudal view. State A: There is a narrow groove (ending with an opening in its upper part) on each side of the foramen occipitale magnum. The openings are approximately at the height of the upper part of the foramen occipitale magnum. State B: There is a narrow groove (ending with an opening in its upper part) on each side of the foramen occipitale magnum. The openings are approximately half-way up the foramen occipitale magnum (or lower). Remark: The openings (in both states) are generally visible in the ventrocaudal view; sometimes they are not visible since they may be at the end of a long canal.

Podiceps cristatus: B = 92%, N = 37
P. g. grisegena: B = 97%, N = 33
P. g. holboellii: B = 100%, N = 29
P. auritus: B = 100%, N = 13
P. nigricollis: B = 100%, N = 11
Tachybaptus ruficollis: B = 100%, N = 24

Rollandia rolland: B = 5 spec., N = 5
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 5 spec., N = 7
Podiceps occipitalis: B = 2 spec., N = 2
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: A = 4 spec., N = 4

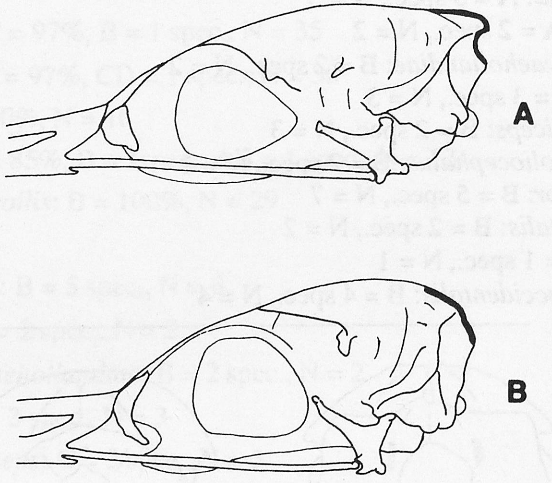

Fig. 10. Cranium 8: lateral view. State A: An elongated crest projects backwards beyond the os parietale. There is a distinct bend between the crest and the os occipitale. State B: There is no crest projecting beyond the os parietale.

Podiceps cristatus: B = 100%, N = 36
P. g. grisegena: B = 100%, N = 33
P. g. holboellii: B = 100%, N = 29
P. auritus: B = 100%, N = 13
P. nigricollis: B = 100%, N = 12
Tachybaptus ruficollis: B = 100%, N = 26

Rollandia rolland: B = 5 spec., N = 5
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 7
Podiceps occipitalis: B = 2 spec., N = 2
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

2. MANDIBULA

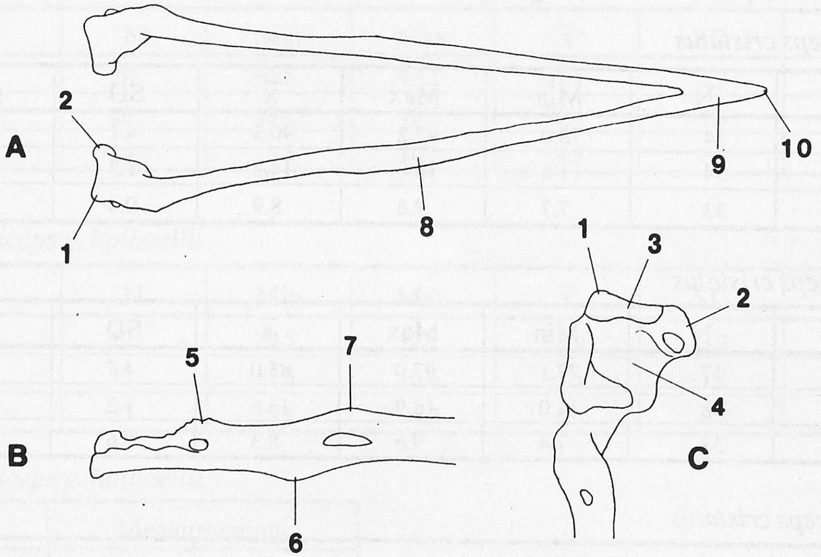

Fig. 11. Mandibula: nomenclature. A – ventral view; B – lateral view; C – articular part, dorsal view. 1 – Processus caudalis; 2 – Processus medialis (mandibulae); 3 – Fossa caudalis; 4 – Fossa dorsalis; 5 – Processus coronoideus; 6 – Processus ventralis; 7 – Angulus mandibulae; 8 – Ramus mandibulae; 9 – Symphysis mandibulae; 10 – Apex mandibulae.

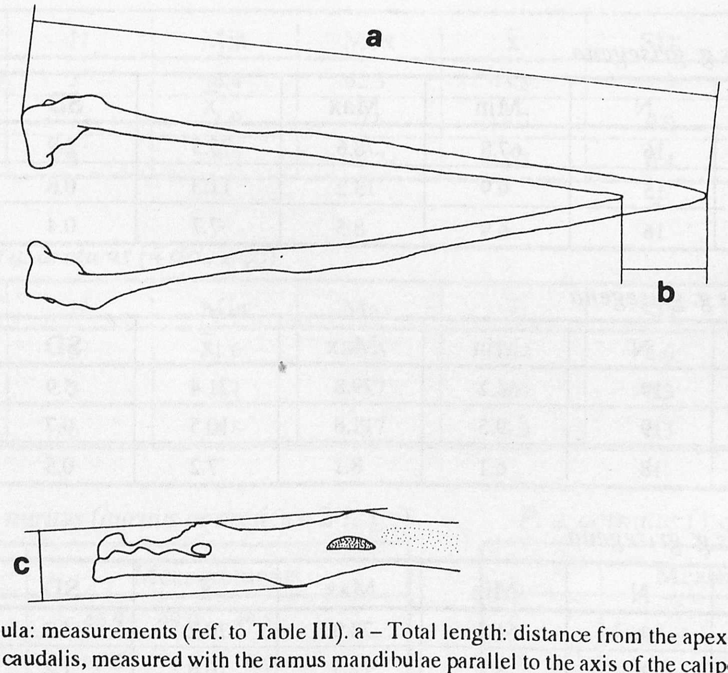

Fig. 12. Mandibula: measurements (ref. to Table III). a – Total length: distance from the apex mandibulae to the processus caudalis, measured with the ramus mandibulae parallel to the axis of the calipers; b – Length of the symphysis mandibulae; c – Height of the ramus mandibulae, measured with the angulus mandibulae, processus coronoideus and processus ventralis flat against the calipers.

Table III

Mandibula (measured as in Fig. 12)

Podiceps cristatus

♂	N	Min	Max	$\overline{x}$	SD	CV
a **	34	78.0	97.2	90.5	4.1	4.5
b *	34	11.6	16.8	14.3	1.3	9.1
c **	33	7.7	9.6	8.9	0.4	4.5

Podiceps cristatus

♀	N	Min	Max	$\overline{x}$	SD	CV
a **	37	77.1	97.0	85.0	4.7	5.5
b *	38	11.0	16.9	13.6	1.3	9.6
c **	38	7.4	9.6	8.3	0.6	7.2

Podiceps cristatus

?	N	Min	Max	$\overline{x}$	SD	CV
a	22	79.1	94.3	87.6	5.3	6.0
b	20	10.2	15.9	12.9	1.4	10.9
c	22	7.3	9.9	8.7	0.6	6.9

Podiceps g. grisegena

♂	N	Min	Max	$\overline{x}$	SD	CV
a **	16	67.8	78.6	75.5	2.9	3.8
b **	15	9.9	13.2	11.3	0.8	7.1
c **	16	6.9	8.5	7.7	0.4	5.2

Podiceps g. grisegena

♀	N	Min	Max	$\overline{x}$	SD	CV
a **	19	64.2	79.8	71.4	3.9	5.5
b **	19	9.5	11.8	10.5	0.7	6.7
c **	18	6.1	8.1	7.2	0.5	6.9

Podiceps g. grisegena

?	N	Min	Max	$\overline{x}$	SD	CV
a	13	61.3	78.9	70.7	4.3	6.1
b	13	8.1	12.5	10.0	1.2	12.0
c	14	6.3	8.2	7.3	0.5	6.8

Table III cont.

Podiceps g. holboellii

♂	N	Min	Max	x̄	SD	CV
a **	28	84.8	98.1	91.1	3.3	3.6
b *	28	13.2	18.5	15.4	1.4	9.1
c **	29	8.5	10.5	9.5	0.5	5.3

Podiceps g. holboellii

♀	N	Min	Max	x̄	SD	CV
a **	17	79.5	92.1	85.9	3.3	3.8
b *	17	12.5	16.6	14.5	1.3	9.0
c **	17	8.1	9.2	8.8	0.3	3.4

Podiceps g. holboellii

?	Measurements
a	86.5
b	14.2
c	8.9

Podiceps a. auritus (7 ?, 1 ♀)

	N	Min	Max	x̄	SD	CV
a	7	46.4	52.5	48.8	2.5	5.1
b	7	4.9	7.6	5.7	0.9	15.8
c	8	4.2	5.2	4.7	0.4	8.5

Podiceps a. arcticus (4 ♂♂, 2 ♀♀)

	N	Min	Max	x̄	SD	CV
a	3	51.6	53.6	52.4	1.0	1.9
b	3	6.1	6.7	6.4	0.3	4.7
c	6	4.8	5.7	5.3	0.3	5.7

Podiceps auritus (*auritus* or *arcticus*; 2 ?, 1 ♀)

	Measurements		
a	46.9	49.0	49.5
b	5.2	6.6	8.6
c	4.3	4.7	5.2

P. a. cornutus (1 ♂)

	Measurements
a	–
b	–
c	4.7

Table III cont.

Podiceps n. nigricollis (12?, 2 ♂♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	12	40.4	47.5	44.5	2.1	4.7
b	12	4.7	6.6	5.6	0.6	10.7
c	13	3.9	4.3	4.1	0.1	2.4

Podiceps n. californicus (3 ♂♂, 1?)

	Measurements			
a	47.9	48.2	49.6	51.2
b	5.5	7.1	7.4	7.5
c	4.0	4.3	4.4	4.4

Tachybaptus r. ruficollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	10	39.2	43.4	41.3	1.3	3.1
b	10	4.0	6.0	4.9	0.6	12.2
c **	10	4.2	5.4	4.5	0.3	6.7

Tachybaptus r. ruficollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	15	37.0	42.4	39.4	1.7	4.3
b	15	3.8	5.5	4.6	0.5	10.9
c **	16	3.7	4.7	4.2	0.3	7.1

Tachybaptus r. ruficollis

?	N	Min	Max	$\bar{x}$	SD	CV
a	19	35.8	42.8	39.5	2.1	5.3
b	21	4.0	5.3	4.6	0.4	8.7
c	20	3.7	4.7	4.2	0.3	7.1

Tachybaptus r. capensis (5?, 1 ♂)

	Measurements					
a	37.2	40.2	40.2	41.9	42.4	43.3
b	4.2	4.5	4.5	4.6	4.7	4.9
c	4.2	4.3	4.3	4.6	4.6	5.0

Table III cont.

Rollandia rolland (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	37.0	40.2	42.9	47.7
b	4.5	4.6	4.7	4.8
c	3.9	4.7	4.9	5.1

Rollandia rolland microptera (1 ♂, 1 ?)

	Measurements	
a	65.0	70.3
b	5.6	7.4
c	7.0	7.6

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	39.0	42.3
b	4.7	4.9
c	4.9	5.1

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements		
a	38.0	41.0	45.8
b	5.5		
c	4.0	4.0	4.9

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	45.5	46.5	53.4	54.0
b	3.3	3.6	4.9	4.9
c	6.0	6.3	7.5	7.8

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	42.0	44.2
b	5.6	5.8
c	4.2	4.6

"*Podiceps*" *major* (3 ?, 2 ♂♂, 2 ♀♀)

	Measurements						
a	100.7	104.2	107.2	108.2	112.6	114.8	115.4
b	23.4	24.3	25.7	26.8	27.0	27.8	29.0
c	9.4	9.5	9.8	10.2	10.2	10.6	10.8

Podiceps occipitalis (2 ♂♂)

	Measurements	
a	38.8	42.9
b	3.1	4.0
c	3.8	4.0

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	54.6
b	7.2
c	4.9

Podiceps gallardoi (1 ?)

	Measurements
a	45.6
b	3.3
c	4.2

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀, 1 ?)

	Measurements				
a	99.1	108.7	109.3	113.0	
b	22.7	23.7	26.9	28.6	
c	8.5	9.0	10.1	10.2	10.5

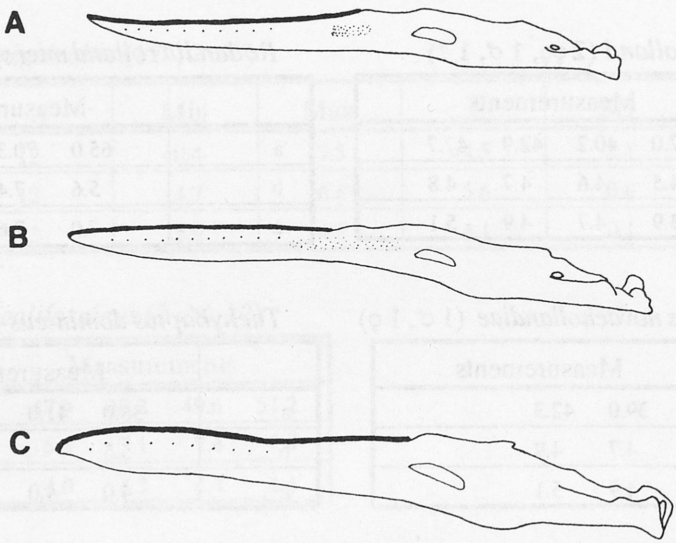

Fig. 13. Mandibula 1: lateral view. The character is better seen when the dorsal edge of the ramus mandibulae (between the apex mandibulae and the angulus mandibulae) is put parallel to a line (e. g. on lined paper). State A: The dorsal edge of the ramus mandibulae (between the apex mandibulae and the angulus mandibulae) bends upwards. State B: The dorsal edge of the ramus mandibulae (between the apex mandibulae and the angulus mandibulae) is approximately straight. State C: The dorsal edge of the ramus mandibulae (between the apex mandibulae and the angulus mandibulae) is wavy (the apex mandibulae points downwards).

Podiceps cristatus: B = 74%, A = 6 spec., AB = 4 spec., N = 39
P. g. grisegena: B = 88%, A = 4 spec., N = 34
P. g. holboellii: B = 89%, A = 3 spec., N = 28
P. auritus: B = 100%, N = 10
P. nigricollis: A = 93%, AB = 1 spec., N = 14
Tachybaptus ruficollis: B = 93%, A = 2 spec., N = 28

Rollandia rolland: B = 3 spec., N = 3
R. microptera: C = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: C = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: A = 7 spec., N = 7
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: A = 4 spec., N = 4

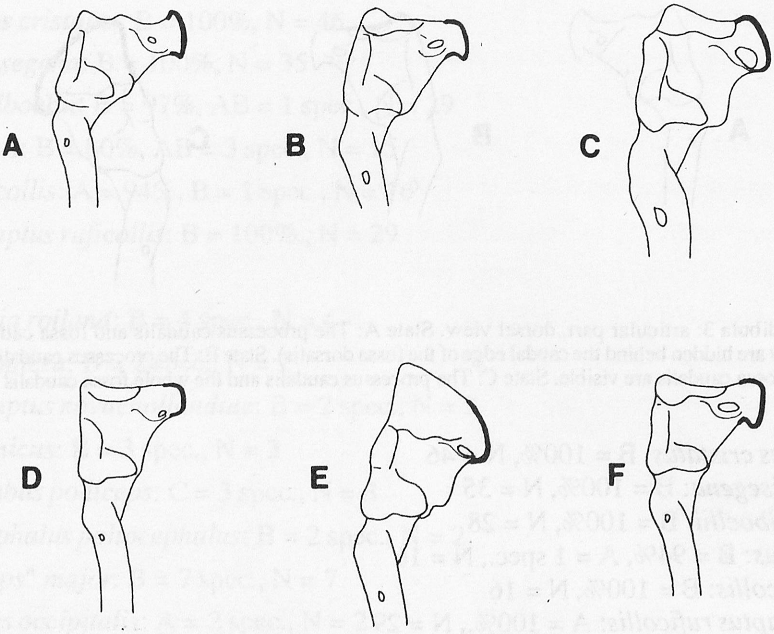

Fig. 14. Mandibula 2: articular part, dorsolateral view. State A: The processus medialis looks like a hatchet. State B: The processus medialis has only one tip pointing to the apex mandibulae. State C: The processus medialis is slanting and it is bulging on its caudal side (at the junction with the processus caudalis). State D: The processus medialis is neither bulging nor with any tips; its end is gently rounded. State E: The processus medialis is slanting but it is not bulging on its caudal side as that one in state C. State F: The processus medialis is slanting but in a different direction from that in states C and E. It is bulging on its caudal side and has a narrow, elongated tip pointing to the apex mandibulae.

Podiceps cristatus: C = 100%, N = 29
P. g. grisegena: C = 100%, N = 35
P. g. holboellii: C = 100%, N = 29
P. auritus: uncharacteristic, N = 15(A, AD, B)
P. nigricollis: B = 80%, AD = 3 spec., N = 15
Tachybaptus ruficollis: A = 97%, AD = 1 spec., N = 29

Rollandia rolland: A = 3 spec., AD = 1 spec., N = 4
R. microptera: A = 2 spec., N = 2
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: C = 3 spec., N = 3
Podilymbus podiceps: A 3 spec., N = 3
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: C = 6 spec., N = 6
Podiceps occipitalis: D = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi: F = 1 spec., N = 1
Aechmophorus occidentalis: E = 4 spec., N = 4

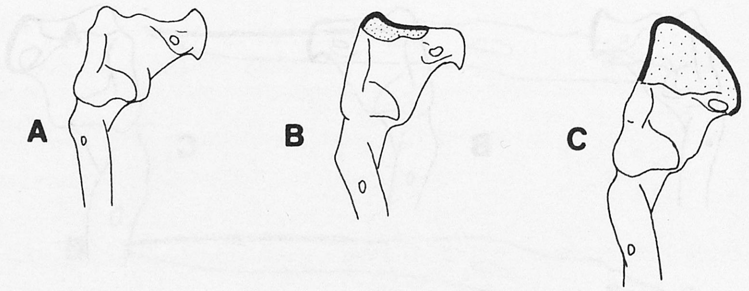

Fig. 15. Mandibula 3: articular part, dorsal view. State A: The processus caudalis and fossa caudalis are no visible (they are hidden behind the caudal edge of the fossa dorsalis). State B: The processus caudalis and a small part of the fossa caudalis are visible. State C: The processus caudalis and the whole fossa caudalis are visible.

Podiceps cristatus: B = 100%, N = 46
P. g. grisegena: B = 100%, N = 35
P. g. holboellii: B = 100%, N = 28
P. auritus: B = 94%, A = 1 spec., N = 16
P. nigricollis: B = 100%, N = 16
Tachybaptus ruficollis: A = 100%., N = 29

Rollandia rolland: A = 3 spec., B = 1 spec., N = 4
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: A = 1 spec., N = 1
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 5 spec., BC = 2 spec., N = 7
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: C = 4 spec., N = 4

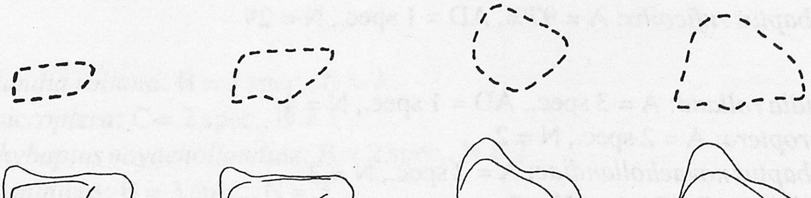

Fig. 16. Mandibula 4: articular part, caudal view. State A: The outline of the fossa caudalis is like a long, narrow rectangle. State B: The outline of the fossa caudalis is trapezium-shaped. The trapezium is relatively much wider than the rectangle in state A. State C: The outline of the fossa caudalis resembles a square in shape. State D: The outline of the fossa caudalis is triangular.

Podiceps cristatus: B = 100%, N = 46
P. g. grisegena: B = 100%, N = 35
P. g. holboellii: B = 97%, AB = 1 spec., N = 29
P. auritus: B = 80%, AB = 3 spec., N = 15
P. nigricollis: A = 94%, B = 1 spec., N = 16
Tachybaptus ruficollis: B = 100%., N = 29

Rollandia rolland: B = 4 spec., N = 4
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: C = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 7 spec., N = 7
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi: A = 1 spec., N = 1
Aechmophorus occidentalis: D = 4 spec., N = 4

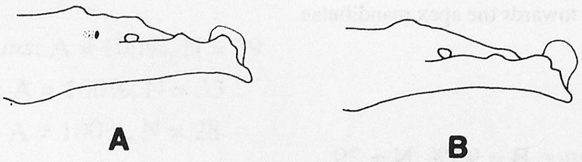

Fig. 17. Mandibula 5: articular part, lateral view. State A: There are two openings (one big and one small) in the lateral surface of the articular part. State B: There is only one big opening in the lateral surface of the articular part. The small opening is lacking.

Podiceps cristatus: A = 97%, N = 39
P. g. grisegena: A = 73%, N = 33
P. g. holboellii: A = 75%, N = 28
P. auritus: A = 92%, N = 13
P. nigricollis: A = 100%, N = 14
Tachybaptus ruficollis: A = 92%, N = 25

Rollandia rolland: A = 4 spec., N = 4

R. microptera: A = 2 spec., N = 2
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 2 spec., N = 3
Podilymbus podiceps: A = 2 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 7 spec., N = 7
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi: A = 1 spec., N = 1
Aechmophorus occidentalis: B = 4 spec., N = 4

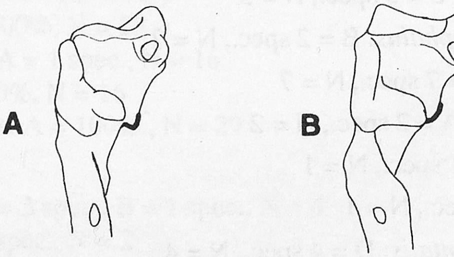

Fig. 18. Mandibula 6: articular part, dorsal view. State A: The medioanterior corner of the fossa dorsalis projects towards the apex mandibulae. State B: The medioanterior corner of the fossa dorsalis is rounded and does not project towards the apex mandibulae.

Podiceps cristatus: B = 95%, N = 39
P. g. grisegena: B = 94%, N = 33
P. g. holboellii: uncharacteristic, N = 28
P. auritus: B = 100%, N = 13
P. nigricollis: B = 100%, N = 14
Tachybaptus ruficollis: B = 100%, N = 25

Rollandia rolland: B = 4 spec., N = 4
R. microptera: B = 2 spec., N = 2
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2

"*Podiceps*" *major*: A = 5 spec., N = 7
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi: B = 1 spec., N = 1
Aechmophorus occidentalis: B = 4 spec., N = 4

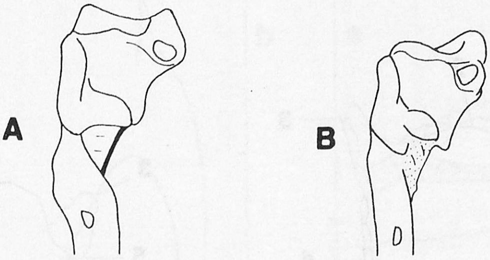

Fig. 19. Mandibula 7: articular part, dorsal view. State A: In the corner between the ramus mandibulae and its articular part, there is a flat, triangular shelf. State B: Instead of a flat, triangular shelf, there is only a steep medial surface of the ramus mandibulae in the corner between the ramus mandibulae and its articular part.

Podiceps cristatus: A = 100%, N = 39
P. g. grisegena: A = 100%, N = 33
P. g. holboellii: A = 100%, N = 28
P. auritus: A = 100%, N = 13
P. nigricollis: A = 100%, N = 14
Tachybaptus ruficollis: A = 100%, N = 25

Rollandia rolland: A = 4 spec., N = 4
R. microptera: A = 2 spec., N = 2
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: A = 7 spec., N = 7
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1

P. gallardoi: A = 1 spec., N = 1

Aechmophorus occidentalis: A = 4 spec., N = 4

3. STERNUM

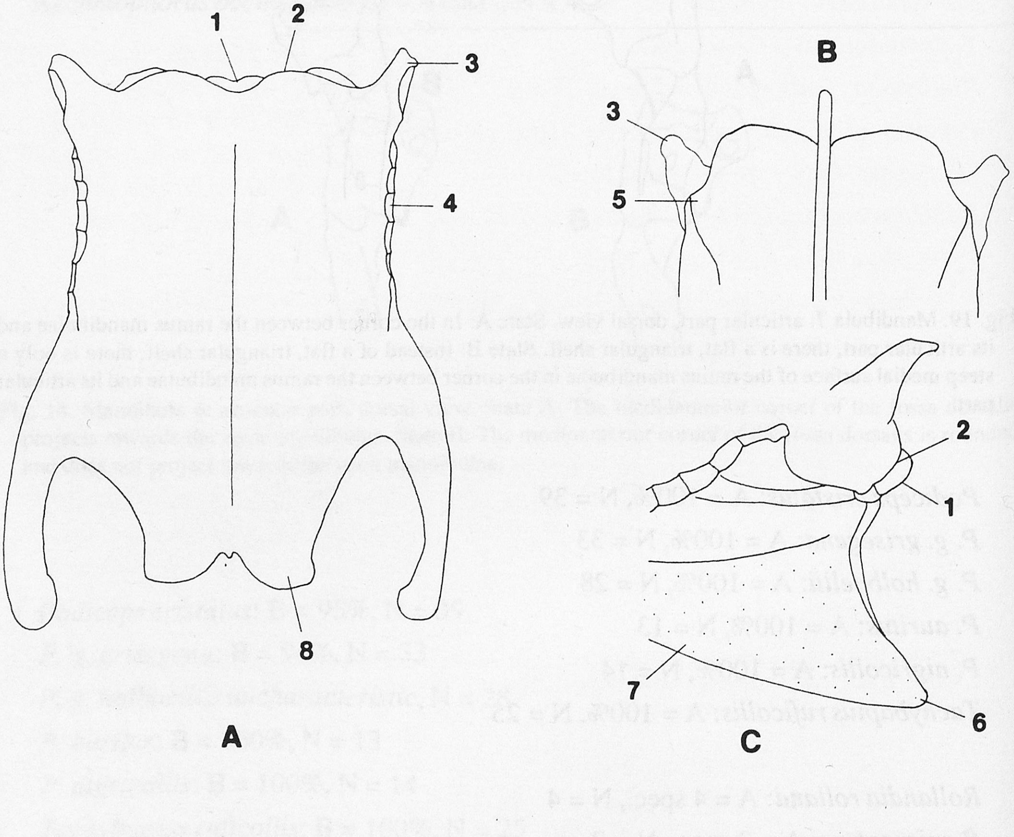

Fig. 20. Sternum: nomenclature. A – dorsal view; B – cranial part, ventral view; C – cranial part, laterocranial view. 1 – Labium ventrale; 2 – Labium dorsale; 3 – Processus praecostalis dorsalis; 4 – Facies articularis costosternalis; 5 – Processus praecostalis ventralis; 6 – Apex cristae sterni; 7 – Crista sterni; 8 – Metasternum.

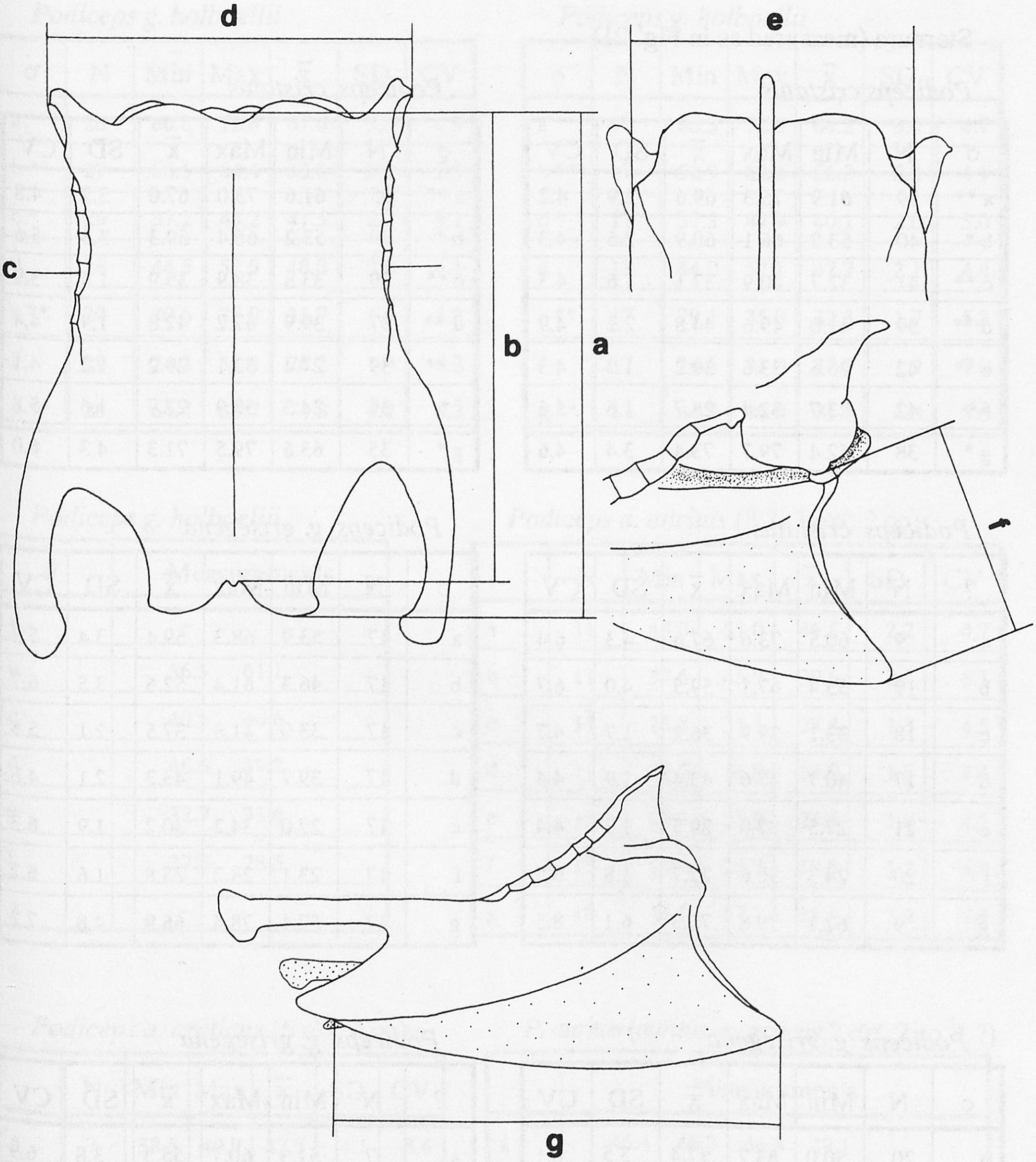

Fig. 21. Sternum: measurements (ref. to Table IV). a – Total length: distance from the tip of the metasternum to the mid-point of the labium dorsale or labium ventrale (whichever gives higher values); b – Sternal length: the longest mid-line measurement, from the bottom of the notch in the metasternum to the mid-point of the labium dorsale or labium ventrale (whichever gives higher values); c – Minimum width of the sternum: the narrowest distance between the facies articularis costosternalis of the left and right sides; d – Dorsal width of the sternum: distance between the left and the right processus praecostalis dorsalis; e – Ventral width of the sternum: distance between the the left and the right processus praecostalis ventralis; f – Height of the crista sterni: distance from the apex cristae sterni to the labium dorsale; g – Length of the crista sterni: distance from the apex cristae sterni to the posteriormost point of the crista sterni.

Table IV

Sternum (measured as in Fig. 21)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	39	61.9	75.3	69.6	2.9	4.2
b *	40	53.9	66.1	60.9	2.6	4.3
c **	41	32.7	40.9	37.1	1.6	4.3
d **	39	41.0	49.6	44.8	2.2	4.9
e **	42	26.6	33.6	30.2	1.3	4.3
f *	42	23.7	32.4	28.7	1.6	5.6
g *	38	62.4	79.7	73.4	3.4	4.6

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	35	61.6	73.0	67.0	3.2	4.8
b *	39	53.2	66.4	59.3	3.3	5.6
c **	39	33.8	38.9	35.9	1.4	3.9
d **	37	39.9	47.2	42.8	1.9	4.4
e **	39	27.4	32.1	29.2	1.2	4.1
f *	39	24.3	30.9	27.7	1.6	5.8
g *	35	63.6	79.5	71.3	4.3	6.0

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	9	60.5	73.6	67.6	4.3	6.4
b	19	53.4	67.1	59.5	4.0	6.7
c	18	33.1	39.9	36.2	1.7	4.7
d	17	40.7	47.6	43.4	1.9	4.4
e	21	27.5	32.0	29.5	1.3	4.4
f	20	24.3	30.6	27.7	1.8	6.5
g	9	62.1	79.8	71.5	6.1	8.5

Podiceps g. grisegena

♂	N	Min	Max	$\bar{x}$	SD	CV
a	17	53.9	68.3	59.4	3.4	5.7
b	17	46.3	61.4	52.6	3.5	6.7
c	17	33.0	41.8	37.5	2.1	5.6
d	17	39.7	49.1	43.3	2.1	4.8
e	17	27.0	34.2	30.2	1.9	6.3
f	17	23.1	28.2	25.8	1.6	6.2
g	17	57.1	78.4	66.9	4.8	7.2

Podiceps g. grisegena

♀	N	Min	Max	$\bar{x}$	SD	CV
a	20	50.0	63.7	57.4	3.5	6.1
b	22	42.8	55.3	50.1	3.7	7.4
c	20	32.3	39.9	35.9	2.1	5.8
d	20	37.3	47.9	41.9	2.9	6.9
e	22	25.3	38.9	29.3	2.9	9.9
f	22	21.3	27.3	24.6	1.8	7.3
g	20	53.8	71.1	63.8	4.7	7.4

Podiceps g. grisegena

?	N	Min	Max	$\bar{x}$	SD	CV
a	7	51.3	60.7	55.3	3.8	6.9
b	11	45.1	55.8	49.7	3.6	7.2
c	9	32.4	36.2	33.9	1.3	3.8
d	11	36.6	43.9	40.1	2.3	5.7
e	13	25.7	31.0	28.2	1.6	5.7
f	12	20.8	27.4	24.3	2.1	8.6
g	7	57.6	64.5	61.5	2.2	3.6

Table IV cont.

Podiceps g. holboellii

♂	N	Min	Max	x̄	SD	CV
a **	28	60.0	72.6	67.0	3.3	4.9
b **	29	50.6	64.4	58.6	3.2	5.5
c *	29	37.2	45.2	41.5	2.1	5.1
d	28	44.5	52.9	48.8	2.0	4.1
e **	29	30.6	38.9	33.7	1.8	5.3
f	29	24.2	31.4	28.2	1.9	6.7
g **	28	64.4	83.7	74.8	4.7	6.3

Podiceps g. holboellii

♀	N	Min	Max	x̄	SD	CV
a **	17	60.3	72.8	64.2	3.0	4.7
b **	17	52.9	62.2	56.3	2.3	4.1
c *	17	37.3	44.9	40.1	2.0	5.0
d	17	44.0	52.1	47.7	2.1	4.4
e **	17	29.1	35.0	32.3	1.7	5.3
f	17	24.5	31.0	27.1	1.9	7.0
g **	17	64.5	79.0	71.1	4.0	5.6

Podiceps g. holboellii

?	Measurements	
a	–	
b	56.5	61.1
c	40.5	40.6
d	46.6	49.2
e	32.7	33.6
f	27.3	28.5
g	–	

Podiceps a. auritus (8 ?, 3 ♂♂, 2 ♀♀)

	N	Min	Max	x̄	SD	CV
a	11	43.0	51.0	46.5	2.2	4.7
b	11	37.6	45.9	39.6	2.4	6.1
c	11	26.8	31.1	28.8	1.3	4.5
d	11	31.5	36.0	34.0	1.5	4.4
e	13	22.9	25.9	24.5	1.0	4.1
f	13	18.0	21.9	19.5	1.2	6.2
g	10	45.1	57.7	51.6	3.9	7.6

Podiceps a. arcticus (6 ♂♂, 4 ♀♀)

	N	Min	Max	x̄	SD	CV
a	7	38.5	49.9	47.7	4.1	8.6
b	10	38.2	44.8	40.8	2.3	5.6
c	10	28.6	33.2	30.7	1.4	4.6
d	10	32.9	37.4	34.8	1.6	4.6
e	10	24.3	27.7	26.2	0.9	3.4
f	10	19.5	22.5	20.7	0.8	3.9
g	7	50.9	55.5	53.5	1.4	2.6

P. auritus (*auritus* or *arcticus*; 2 ♂♂, 2 ♀♀, 1 ?)

	Measurements				
a	46.4	46.7	46.8	49.1	
b	36.1	38.0	40.0	41.1	42.4
c	27.6	27.8	29.7	30.4	
d	32.7	32.8	33.1	33.8	34.4
e	23.4	24.4	25.1	25.8	
f	19.1	19.4	19.5	20.2	21.3
g	48.1	51.2	51.4	55.9	

Table IV cont.

Podiceps a. cornutus (1 ♂)

	Measurements
a	–
b	42.1
c	30.1
d	34.7
e	25.3
f	20.2
g	–

Podiceps n. nigricollis (11 ?, 9 ♂♂, 9 ♀♀; no significant differences between sexes)

	N	Min	Max	x̄	SD	CV
a	23	39.9	48.7	45.2	2.0	4.4
b	27	35.7	55.9	41.0	3.6	8.8
c	25	24.5	33.1	27.9	1.8	6.5
d	25	28.9	42.5	31.6	2.5	7.9
e	27	22.0	27.6	23.7	1.2	5.1
f	29	16.6	25.6	19.2	1.6	8.3
g	22	42.4	54.6	50.1	3.0	6.0

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	42.5	43.3	46.1	46.7
b	36.0	38.4	39.4	42.3
c	26.6	27.3	28.1	
d	29.5	29.7	31.8	
e	22.7	23.0	24.4	24.8
f	16.9	17.2	17.6	18.0
g	45.3	47.7	47.7	51.6

Tachybaptus r. ruficollis

♂	N	Min	Max	x̄	SD	CV
a	7	31.5	35.4	33.8	1.6	4.7
b	9	24.8	33.4	27.7	2.6	9.4
c	9	20.9	25.0	22.7	1.3	5.7
d	8	24.7	28.0	26.0	1.1	4.2
e	9	19.6	22.0	20.6	0.7	3.4
f *	9	11.4	12.7	12.3	0.4	3.3
g	7	30.3	35.1	32.7	2.1	6.4

Tachybaptus r. ruficollis

♀	N	Min	Max	x̄	SD	CV
a	15	31.4	35.3	33.4	1.2	3.6
b	16	25.6	30.2	27.2	1.2	4.4
c	15	20.7	23.0	21.8	0.7	3.2
d	16	23.7	26.9	25.3	0.9	3.6
e	16	19.2	21.0	19.9	0.6	3.0
f *	17	10.1	12.8	11.8	0.6	5.1
g	16	29.5	35.1	31.8	1.5	4.7

Tachybaptus r. ruficollis

?	N	Min	Max	x̄	SD	CV
a	19	31.0	36.5	33.2	1.4	4.2
b	24	24.5	29.1	27.0	1.2	4.4
c	23	20.2	22.7	21.4	0.7	3.3
d	21	23.0	26.8	24.8	1.1	4.4
e	23	18.3	20.9	19.5	0.6	3.1
f	23	10.2	12.7	11.6	0.7	6.0
g	20	27.7	33.7	31.4	1.5	4.8

Tachybaptus r. capensis (5 ?, 1 ♂)

	Measurements					
a	30.9	33.5				
b	25.9	26.5	27.0	28.7	28.8	
c	19.2	20.0	21.0	21.1	22.2	23.0
d	22.8	23.4	24.7	25.7	26.0	27.0
e	18.1	18.7	19.5	19.6	20.8	21.6
f	9.8	11.5	12.0	12.4	12.6	
g	29.5	33.3				

Table IV cont.

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	36.1		
b	28.5	29.8	32.7
c	20.1	21.1	22.5
d	24.6	25.6	27.9
e	18.8	18.9	20.0
f	10.1	12.3	13.2
g	31.2		

Rollandia microptera (1 ♂)

	Measurements
a	–
b	33.7
c	32.0
d	38.4
e	28.2
f	6.5
h	–

Tachybaptus novaehollandiae (1 ♂, 1 a)

	Measurements	
a	34.3	
b	29.7	31.5
c	21.0	21.2
d	23.9	24.7
e	19.2	19.9
f	13.5	14.1
g	36.5	

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	28.6			
b	22.8	22.9	24.4	24.7
c	18.0	18.0	20.3	20.4
d	21.0	22.2	22.8	23.5
e	16.5	16.6	18.1	18.4
f	10.0	10.0	10.7	11.4
g	27.1			

Podilymbus podiceps (2 ♀♀, 1 b, 1 ?)

	Measurements			
a	43.5	44.9	51.5	
b	31.1	34.4	34.9	40.0
c	22.3	25.5	25.7	26.3
d	29.2	31.2	33.2	33.2
e	19.7	22.0	23.0	23.8
f	15.1	16.1	18.3	
g	42.3	47.6		

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	37.7	37.8
b	31.5	35.4
c	21.9	22.4
d	25.4	26.5
e	19.3	20.0
f	15.4	16.0
g	41.0	42.8

Table IV cont.

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	61.2	
b	50.6	56.5
c	39.8	43.0
d	47.2	48.5
f	24.1	25.0
g	61.7	
h	43.9	

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	–		
b	38.6	39.1	
c	27.3	28.2	29.6
d	29.0	30.7	
e	22.8	24.3	25.1
g	45.4	47.2	
h	30.4	30.5	

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	37.5
c	29.8
d	30.3
e	25.2
f	9.8
g	31.8
h	31.2

Podiceps gallardoi ? (1 ?)

	Measurements
a	–
b	–
c	–
d	–
e	–
f	19.6
g	–

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	62.2	69.0	71.5	
b	54.7	58.4	61.9	62.9
d	48.0	52.2	53.2	53.2
e	30.4	30.6	31.7	32.2
f	25.0	26.2	26.3	28.0
g	68.7	74.0	75.0	
h	46.0	50.5	51.2	

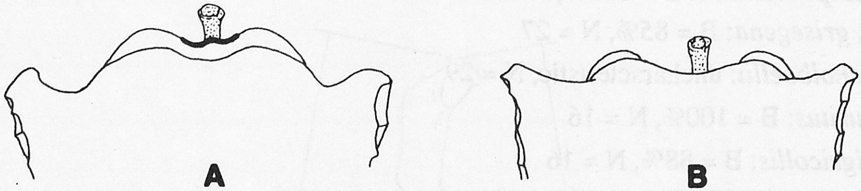

Fig. 22. Sternum 1: cranial part, dorsal view. State A: The medial part of the labium ventrale is well-seen because it protrudes from under the labium dorsale. State B: The medial part of the labium ventrale does not protrude from under the labium dorsale (it is either poorly-seen or not visible at all).

Podiceps cristatus: A = 100%, N = 43
P. g. grisegena: B = 92%, N = 39
P. g. holboellii: B = 97%, N = 30
P. auritus: B = 100%, N = 18
P. nigricollis: B = 91%, N = 22
Tachybaptus ruficollis: B = 91%, N = 33

Rollandia rolland: B = 2 spec., N = 2
R. micropterа: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 3 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occipitalis: B = 3 spec., N = 3

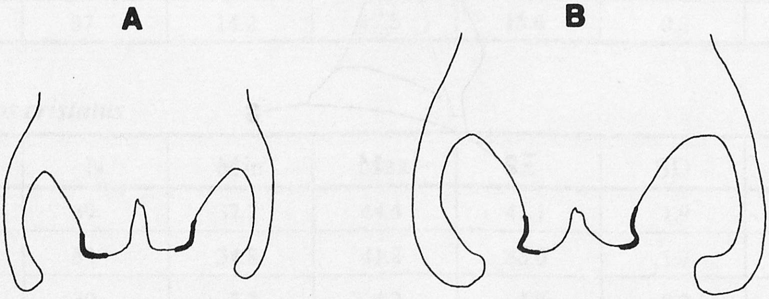

Fig. 23. Sternum 2: caudal part, dorsal view. State A: Both parts of the metasternum are broad; there are no distinct tips on them. State B: There is a sharp-pointed tip on each part of the metasternum.

Podiceps cristatus: B = 100%, N = 29
P. g. grisegena: B = 85%, N = 27
P. g. holboellii: uncharacteristic, N = 29
P. auritus: B = 100%, N = 16
P. nigricollis: B = 88%, N = 16
Tachybaptus ruficollis: A = 85%, N = 27

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Aechmophorus occipitalis: uncharacteristic, N = 3

4. CORACOIDEUM

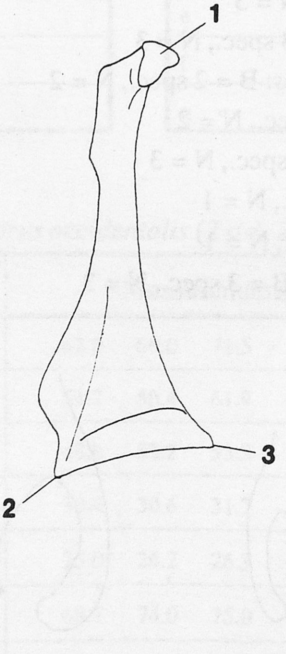

Fig. 24. Coracoideum: nomenclature. Cranial view. 1 – Acrocoracoid; 2 – Apex lateralis; 3 – Apex medialis.

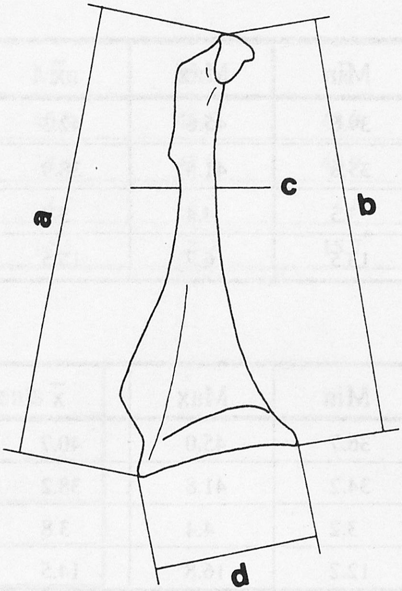

Fig. 25. Coracoideum: measurements (ref. to Table V). a – Total length: distance from the acrocoracoid to the apex lateralis; b – Medial length: distance from the acrocoracoid to the apex medialis; c – Minimum width of the shaft; d – Width of the facies articularis basalis: distance from the apex lateralis to the apex medialis.

Table V

Coracoideum (measured as in Fig. 25)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	42	38.8	45.1	42.8	1.5	3.5
b **	42	36.0	41.8	39.5	1.3	3.3
c **	42	3.6	4.5	4.0	0.2	5.0
d *	37	14.2	17.3	15.6	0.8	5.1

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	39	37.7	44.4	41.1	1.9	4.6
b **	39	34.8	41.2	38.0	1.7	4.5
c **	39	3.3	4.2	3.8	0.2	5.3
d *	35	13.4	16.8	15.1	1.0	6.6

Table V cont.

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	23	39.6	45.6	42.3	1.8	4.3
b	23	35.6	41.6	38.9	1.5	3.9
c	23	3.5	4.4	3.9	0.2	5.1
d	13	13.5	16.7	15.5	1.0	6.5

Podiceps g. grisegena

♂	N	Min	Max	$\bar{x}$	SD	CV
a *	18	36.7	45.0	40.7	2.1	5.2
b	18	34.2	41.8	38.2	2.0	5.2
c	18	3.2	4.4	3.8	0.3	7.9
d *	17	12.2	16.8	14.5	1.1	7.6

Podiceps g. grisegena

♀	N	Min	Max	$\bar{x}$	SD	CV
a *	22	34.9	43.7	38.9	2.6	6.7
b	22	32.8	41.0	36.7	2.6	7.1
c	22	3.0	4.3	3.6	0.3	8.3
d *	20	11.5	15.1	13.7	1.2	8.8

Podiceps g. grisegena

?	N	Min	Max	$\bar{x}$	SD	CV
a	13	34.6	41.0	38.0	2.2	5.8
b	13	32.5	38.7	35.6	2.1	5.9
c	13	3.0	4.2	3.5	0.4	11.4
d	9	11.7	15.7	13.2	1.2	9.1

Podiceps g. holboellii

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	29	41.4	48.8	45.8	1.8	3.9
b **	29	36.9	46.3	42.5	1.9	4.5
c *	29	3.7	4.9	4.3	0.3	7.0
d **	28	14.8	18.6	16.7	0.8	4.8

Table V cont.

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	17	40.8	46.5	43.9	1.9	4.3
b **	17	38.4	42.9	40.9	1.6	3.9
c *	17	3.7	4.5	4.1	0.3	7.3
d **	17	14.1	16.7	15.7	0.8	5.1

Podiceps g. holboellii

?	Measurements	
a	43.9	44.1
b	40.5	41.0
c	4.0	4.5
d	–	

Podiceps a. auritus (9 ?, 3 ♂♂, 2 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	14	27.6	31.9	30.0	1.4	4.7
b	13	25.9	30.5	28.3	1.4	4.9
c	14	2.4	3.0	2.7	0.2	7.4
d	12	10.4	12.6	11.4	0.8	7.0

Podiceps a. arcticus (6 ♂♂, 4 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	10	29.8	33.8	32.2	1.2	3.7
b	10	28.1	31.5	30.0	1.0	3.3
c	10	2.8	3.2	3.0	0.2	6.7
d	7	10.9	12.8	12.0	0.7	5.8

Podiceps auritus (*auritus* or *arcticus*; 2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	29.1	29.3	29.4	29.8
b	27.3	27.4	27.7	27.8
c	2.5	2.6	2.6	2.7
d	10.5	10.8	11.1	

Podiceps a. cornutus (1 ♂)

	Measurements
a	31.3
b	29.1
c	2.6
d	–

Table V cont.

Podiceps n. nigricollis

♂	N	Min	Max	x̄	SD	CV
a *	9	28.8	31.3	30.1	0.9	3.0
b *	9	27.3	29.5	28.4	0.7	2.5
c	9	2.5	2.7	2.6	0.1	3.8
d	8	10.3	11.5	11.1	0.4	3.6

Podiceps n. nigricollis

♀	N	Min	Max	x̄	SD	CV
a *	9	26.2	30.0	28.6	1.2	4.2
b *	9	25.0	28.7	27.2	1.2	4.4
c	9	2.3	2.8	2.6	0.1	3.8
d	9	9.7	11.9	10.9	0.8	7.3

Podiceps n. nigricollis

?	N	Min	Max	x̄	SD	CV
a	14	27.1	30.8	29.2	1.2	4.1
b	14	25.4	29.6	27.7	1.3	4.7
c	14	2.4	2.8	2.6	0.1	3.8
d	11	9.7	11.8	10.9	0.7	6.4

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	28.4	30.0	30.0	30.5
b	27.2	28.6	28.7	28.8
c	2.5	2.6	2.8	2.8
d	10.3	10.5	11.2	12.1

Tachybaptus r. ruficollis

♂	N	Min	Max	x̄	SD	CV
a *	9	23.5	26.2	24.7	0.9	3.6
b	9	22.3	25.2	23.5	1.0	4.3
c	9	1.7	2.0	1.9	0.1	5.3
d	6	7.2	8.6	8.0	0.5	6.2

Table V cont.

Tachybaptus r. ruficollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a *	17	22.2	24.9	23.8	0.8	3.4
b	17	21.3	23.8	22.8	0.7	3.1
c	17	1.7	2.1	1.9	0.1	5.3
d	16	7.4	8.9	8.1	0.4	4.9

Tachybaptus r. ruficollis

?	N	Min	Max	$\bar{x}$	SD	CV
a	25	22.0	25.8	23.7	1.0	4.2
b	24	20.8	24.4	22.7	1.0	4.4
c	25	1.6	2.1	1.9	0.1	5.3
d	20	7.2	8.6	7.8	0.4	5.1

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	8	21.9	25.3	23.8	1.3	5.5
b	8	20.7	24.2	22.7	1.4	6.2
c	8	1.5	2.0	1.8	0.2	11.1
d	2	7.9	8.4	-	-	-

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	24.7	24.8	24.9
b	23.7	23.9	24.0
c	1.9	2.0	2.0
d	8.7		

Rollandia microptera (1 ♂)

	Measurements
a	32.6
b	31.6
c	2.4
d	–

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	23.5	24.6
b	22.1	23.5
c	1.9	2.0
d	9.4	

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	20.9	21.5	22.4	23.1
b	20.2	20.5	21.6	22.4
c	1.4	1.7	1.7	1.8
d	7.3			

Table V cont.

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	27.4	29.6	32.7	35.6
b	26.4	27.9	30.9	33.2
c	2.1	2.5	2.5	2.7
d	10.0	10.5	11.8	

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	25.9	27.6
b	24.6	26.3
c	2.2	2.5
d	9.4	9.7

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	41.4	45.4
b	37.9	40.9
c	4.0	4.1
d	–	

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	26.7	28.5	28.6
b	25.6	26.6	27.1
c	2.4	2.8	2.8
d	11.1	11.8	

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	27.3
b	25.8
c	2.1
d	9.9

Podiceps gallardoi ? (1 ?)

	Measurements
a	33.1
b	30.8
c	3.2
d	13.0

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	46.7	50.3	51.0	51.1
b	44.5	48.0	48.4	48.7
c	3.8	4.0	4.3	4.3
d	12.8	14.8	14.9	

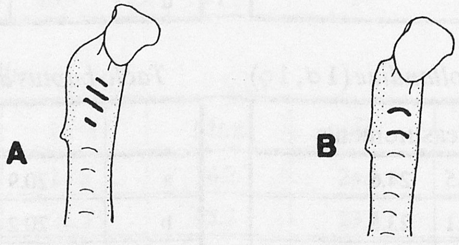

Fig. 26. Coracoideum 1: scapular part, cranial view. State A: The shaft of the coracoideum (just below the acrocoracoid) is flattened. State B: The shaft of the coracoideum below the acrocoracoid is rounded.

Podiceps cristatus: uncharacteristic, N = 43
P. g. grisegena: uncharacteristic, N = 35
P. g. holboellii: B = 70%, N = 30
P. auritus: B = 72%, N = 18
P. nigricollis: A = 95%, N = 21
Tachybaptus ruficollis: uncharacteristic, N = 32

Rollandia rolland: B = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 2 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: A = 2 spec., N = 3
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: B = 2 spec., N = 3

5. CLAVICULA

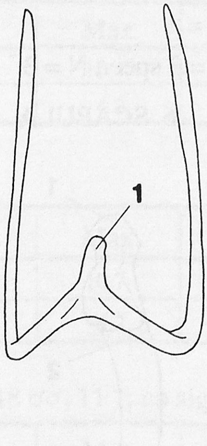

Fig. 27. Clavicula: nomenclature. Ventrocaudal view. 1 – Hypocleidium.

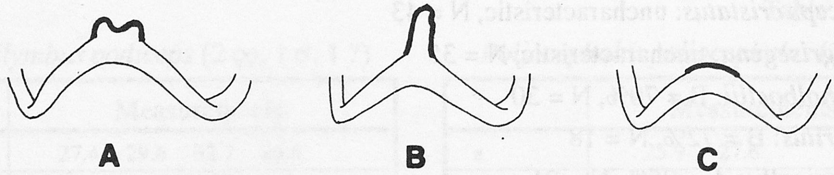

Fig. 28. Clavicula 1: sternal part, ventroaudal view. State A: The hypocleidium consists of two knobs. State B: The hypocleidium forms one rod varying in shape. State C: The hypocleidium is absent; instead, a poorly-seen impression may be present in this place.

Podiceps cristatus: B = 98%, A = 1 spec., N = 46
P. g. grisegena: A = 80%, B = 7 spec., N = 35
P. g. holboellii: A = 97%, C = 1 spec., N = 30
P. auritus: B = 100%, N = 18
P. nigricollis: B = 100%, N = 21
Tachybaptus ruficollis: B = 79%, A = 5 spec., C = 1 spec., N = 29

Rollandia rolland: C = 2 spec., N = 2
R. microptera: C = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N =2
T. dominicus: B = 2 spec., N = 2
Podilymbus podiceps: uncharacteristic (AC = 1 spec., BC = 2 spec., N = 3)
Poliocephalus poliocephalus: uncharacteristic (A = 1 spec., B = 1 spec., N = 2)
"*Podiceps*" *major*: uncharacteristic (A = 1 spec., C = 1 spec., N = 2)
Podiceps occipitalis: B = 2 spec., C = 1 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

6. SCAPULA

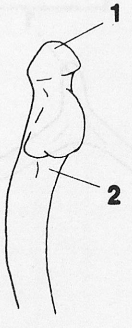

Fig. 29. Scapula: nomenclature. Articular part, lateral view. 1 – Acromion; 2 – Collum scapulae.

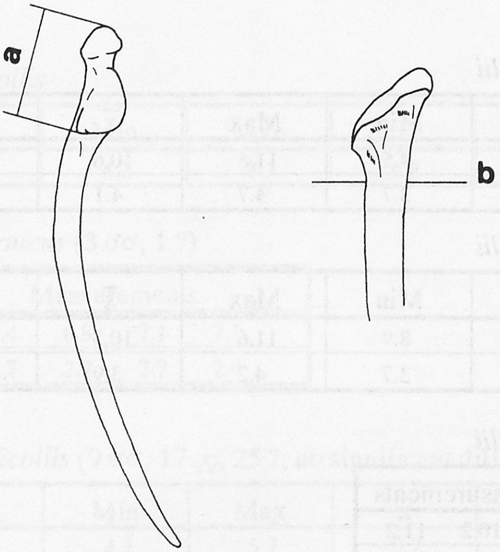

Fig. 30. Scapula (ref. to Table VI): measurements. a – Maximum articular length; b – Width of the collum scapulae, measured just below the articular part.

Table VI

Scapula (measured as in Fig. 30)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	41	9.0	11.0	9.8	0.5	5.1
b	41	3.4	4.3	3.8	0.2	5.3

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	39	8.4	10.4	9.4	0.4	4.3
b	39	3.2	4.2	3.7	0.2	5.4

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	22	8.5	10.7	9.7	0.6	6.2
b	22	3.5	4.2	3.8	0.2	5.3

Podiceps g. grisegena (22 ♀♀, 18 ♂♂, 11 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	51	7.6	10.4	8.9	0.6	6.7
b	50	3.1	4.2	3.6	0.3	8.3

Table VI cont.

Podiceps g. holboellii

♂	N	Min	Max	$\bar{x}$	SD	CV
a	29	9.5	11.6	10.6	0.6	5.7
b *	29	3.7	4.7	4.1	0.3	7.3

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a	17	8.9	11.6	10.3	0.8	7.8
b *	17	3.7	4.2	3.9	0.2	5.1

Podiceps g. holboellii

?	Measurements	
a	10.2	11.2
b	3.9	4.2

Podiceps a. auritus (9 ?, 3 ♂♂, 2 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	14	6.2	7.5	7.0	0.4	5.7
b	14	2.5	3.1	2.8	0.2	7.1

Podiceps a. arcticus (6 ♂♂, 4 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	10	6.6	8.2	7.4	0.4	5.4
b	10	2.6	3.2	3.0	0.2	6.7

Podiceps auritus (*auritus* or *arcticus*; 2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	6.6	7.1	7.2	7.3
b	2.7	2.7	2.8	3.0

Podiceps a. cornutus (1 ♂)

	Measurements
a	7.2
b	2.8

Podiceps n. nigricollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a	9	6.6	7.2	6.9	0.2	2.9
b *	9	2.6	3.0	2.8	0.1	3.6

Podiceps n. nigricollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a	9	6.3	7.4	6.7	0.3	4.5
b *	9	2.4	2.8	2.6	0.1	3.8

Table VI cont.

Podiceps n. nigricollis

?	N	Min	Max	$\overline{x}$	SD	CV
a	12	6.2	7.3	6.8	0.3	4.4

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	6.4	6.8	7.1	7.1
b	2.7	2.7	2.7	2.9

Tachybaptus r. ruficollis (9 ♂♂, 17 ♀♀, 25 ?; no significant differences between sexes)

	N	Min	Max	$\overline{x}$	SD	CV
a	50	4.7	5.7	5.2	0.2	3.8
b	51	1.7	2.4	2.0	0.1	5.0

Tachybaptus r. capensis (5 ?, 1 ♂)

	Measurements					
a	4.5	4.7	5.1	5.1	5.3	5.7
b	1.7	1.8	1.8	1.9	2.0	2.0

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	5.2	5.5	5.6
b	1.8	2.0	2.2

Rollandia microptera (1 ♂)

	Measurements
a	6.8
b	2.1

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	5.3	5.4
b	1.8	2.0

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	4.1	4.2	4.4	5.0
b	1.5	1.5	1.6	2.0

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	5.6	6.4	6.8	7.5
b	2.0	2.2	2.6	2.7

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	5.7	6.0
b	2.3	2.4

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	9.0	9.2
b	3.8	3.9

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	6.5	7.1	7.2
b	2.8	2.9	3.0

Table VI cont.

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	6.0
b	2.6

Podiceps gallardoi ? (1 ?)

	Measurements
a	8.4
b	3.1

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	10.0	10.1	10.4	11.3
b	3.6	3.7	4.0	4.0

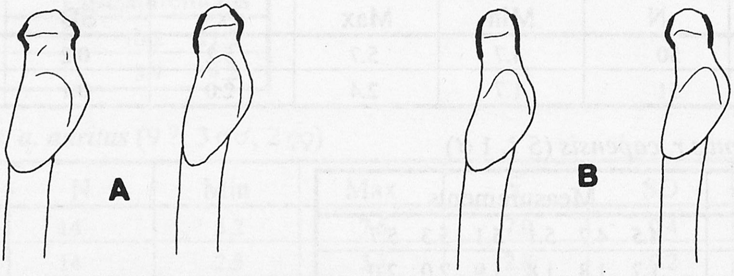

Fig. 31. Scapula 1: articular part, lateral view. State A: The acromion is bulging on both sides or only on the ventral (i. e. right) side. State B: The acromion is bulging only on the dorsal (i. e. left) side or it is not bulging at all.

Podiceps cristatus: A = 79%, N = 39
P. g. grisegena: B = 73%, N = 33
P. g. holboellii: uncharacteristic, N = 30
P. auritus: A = 100%, N = 18
P. nigricollis: B = 75%, N = 20
Tachybaptus ruficollis: A = 71%, N = 31

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 3 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

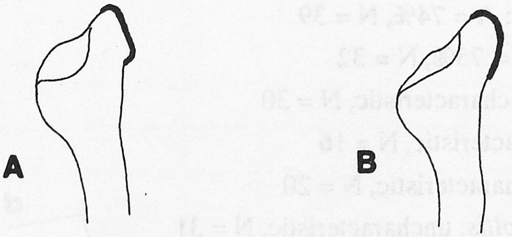

Fig. 32. Scapula 2: articular part, ventral view. State A: The furcular side of the acromion is straight; its transition to the collum scapulae is angular. State B: The furcular side of the acromion is rounded; its transition to the collum scapulae is gradual.

Podiceps cristatus: B = 100%, N = 39
P. g. grisegena: B = 81%, N 32
P. g. holboellii: B = 87%, N = 30
P. auritus: B = 94%, N = 18
P. nigricollis: B = 100%, N = 20
Tachybaptus ruficollis: A = 100%, N = 31

Rollandia rolland: B = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: uncharacteristic, N = 3
Podilymbus podiceps: uncharacteristic, N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 3 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

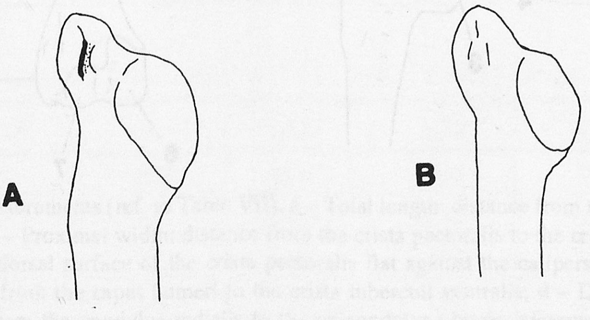

Fig. 33. Scapula 3: articular part, dorsal view. State A: There is a notch between the acromion and the rest of the articular part. State B: The acromion passes gradually into the rest of the articular part, there being no notch.

Podiceps cristatus: A = 74%, N = 39
P. g. grisegena: B = 75%, N = 32
P. g. holboellii: uncharacteristic, N = 30
P. auritus: uncharacteristic, N = 16
P. nigricollis: uncharacteristic, N = 20
Tachybaptus ruficollis: uncharacteristic, N = 31

Rollandia rolland: uncharacteristic, N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: uncharacteristic, N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: A = 2 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): uncharacteristic, N = 1
Aechmophorus occidentalis: uncharacteristic, N = 3

7. HUMERUS

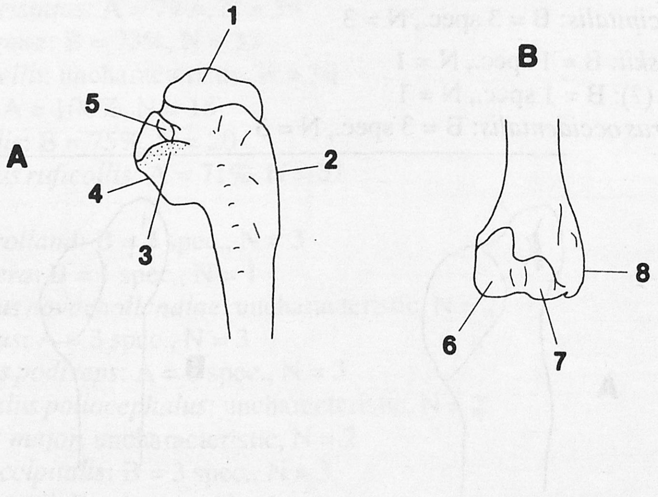

Fig. 34. Humerus: nomenclature. A - proximal part, caudal view; B - distal part, cranial view. 1 – Caput humeri; 2 – Crista pectoralis; 3 – Fossa pneumatica; 4 – Crista tuberculi ventralis; 5 – Tuberculum ventrale; 6 – Condylus radialis; 7 – Condylus ulnaris; 8 – Epicondylus ulnaris.

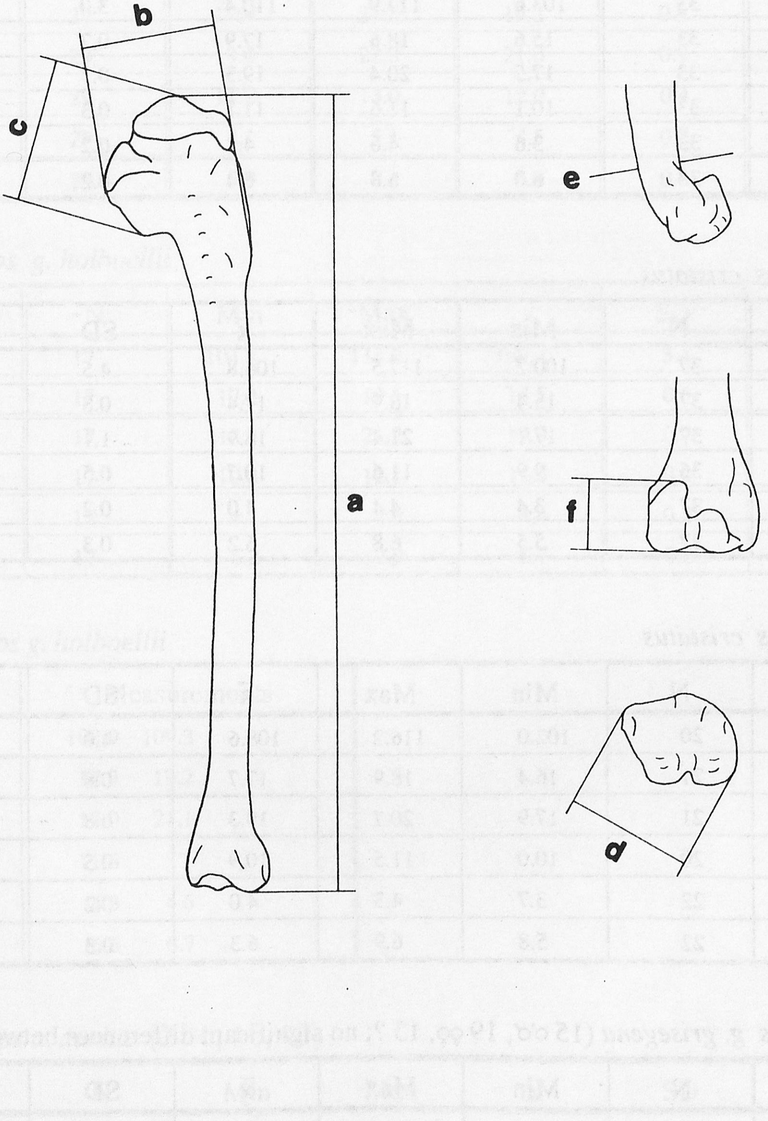

Fig. 35. Humerus: measurements (ref. to Table VII). a – Total length: distance from the caput humeri to the condylus radialis; b – Proximal width: distance from the crista pectoralis to the crista tuberculi ventralis, measured with the dorsal surface of the crista pectoralis flat against the calipers; c – Proximal height: maximum distance from the caput humeri to the crista tuberculi ventralis; d – Distal width: maximum diagonal distance from the condylus radialis to the epicondylus ulnaris, measured with the bone shaft perpendicular to the axis of the calipers; e – Thickness of the shaft: minimum distance between the caudal and cranial surfaces, measured at the neck of the distal part; f – Height of the condylus radialis, measured with the distal tips of the condylus radialis and condylus ulnaris flat against the calipers.

Table VII

Humerus (measured as in Fig. 35)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	33	103.6	117.9	110.4	3.0	2.7
b *	33	15.6	18.6	17.9	0.7	3.9
c	33	17.5	20.4	19.3	0.7	3.6
d **	33	10.1	11.6	11.1	0.3	2.7
e	33	3.6	4.6	4.1	0.2	4.9
f *	33	6.0	6.8	6.4	0.2	3.1

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	37	100.2	117.5	106.8	4.5	4.2
b *	37	15.4	18.9	17.4	0.8	4.6
c	37	17.1	21.4	18.9	1.1	5.8
d **	36	9.9	11.6	10.7	0.5	4.7
e	37	3.4	4.4	4.0	0.2	5.0
f *	37	5.5	6.8	6.2	0.3	4.8

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	20	102.0	116.2	108.6	4.0	3.7
b	21	16.4	18.9	17.7	0.8	4.5
c	21	17.9	20.7	19.3	0.8	4.1
d	20	10.0	11.5	10.9	0.5	4.6
e	22	3.7	4.3	4.0	0.2	5.0
f	22	5.8	6.9	6.3	0.3	4.8

Podiceps g. grisegena (15 ♂♂, 19 ♀♀, 13 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	47	84.9	106.9	98.0	5.3	5.4
b	47	14.4	18.2	16.4	1.0	6.1
c	47	15.1	19.6	17.6	1.2	6.8
d	43	9.1	11.4	10.4	0.6	5.8
e	47	3.2	4.6	3.8	0.3	7.9
f	46	5.1	6.5	5.9	0.4	6.8

Table VII cont.

Podiceps g. holboellii

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	29	101.3	120.8	113.4	4.1	3.6
b **	29	17.9	21.2	19.2	0.8	4.2
c **	29	19.4	22.8	21.0	0.9	4.3
d **	29	11.2	13.0	12.0	0.4	3.3
e *	29	4.1	5.1	4.5	0.2	4.4
f **	29	5.9	7.4	6.9	0.3	4.3

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	17	104.8	115.0	109.4	3.4	3.1
b **	17	17.2	19.5	18.5	0.6	3.2
c **	17	18.7	21.2	19.9	0.7	3.5
d **	17	10.8	12.1	11.5	0.3	2.6
e *	17	4.1	4.8	4.4	0.2	4.5
f **	17	6.2	7.0	6.7	0.2	3.0

Podiceps g. holboellii

?	Measurements	
a	108.9	109.3
b	17.9	19.2
c	19.0	21.1
d	11.6	
e	4.3	4.6
f	6.6	6.7

Podiceps a. auritus (2 ♂♂, 1 ♀, 9 ?)

	N	Min	Max	$\bar{x}$	SD	CV
a	12	67.2	78.4	74.4	3.5	4.7
b	12	11.7	13.4	12.5	0.6	4.8
c	12	12.3	15.3	13.3	1.0	7.5
d	11	7.1	8.3	7.6	0.4	5.3
e	12	2.5	3.0	2.8	0.2	7.1
f	12	4.0	4.8	4.4	0.3	6.8

Table VII cont.

Podiceps a. arcticus (5 ♂♂, 4 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	8	75.4	84.3	78.7	3.2	4.1
b	9	12.2	14.2	13.2	0.6	4.5
c	9	13.6	15.3	14.3	0.5	3.5
d	8	7.8	8.7	8.2	0.3	3.7
e	8	2.9	3.3	3.1	0.2	6.5
f	8	4.3	5.0	4.8	0.2	4.2

Podiceps auritus (*auritus* or *arcticus*; 1 ♂, 1 ♀, 1 ?)

	Measurements		
a	71.8	72.2	73.6
b	12.3	12.3	12.4
c	12.9	13.1	13.3
d	7.6	7.6	7.7
e	2.7	2.8	2.8
f	4.3	4.4	4.6

Podiceps a. cornutus (1 ♂)

	Measurements
a	76.9
b	13.3
c	13.9
d	7.8
e	2.9
f	4.5

Podiceps n. nigricollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a *	6	71.2	73.6	72.1	0.9	1.2
b	7	11.6	12.9	12.3	0.5	4.1
c *	7	12.3	13.2	12.9	0.3	2.3
d	5	7.3	7.9	7.6	0.3	3.9
e	6	2.7	3.0	2.8	0.1	3.6
f *	6	4.3	4.6	4.5	0.1	2.2

Podiceps n. nigricollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a *	8	61.5	73.4	67.8	3.5	5.2
b	8	11.0	12.8	11.8	0.6	5.1
c *	8	11.4	13.3	12.2	0.7	5.7
d	8	7.0	7.8	7.3	0.3	4.1
e	8	2.5	3.0	2.8	0.2	7.1
f *	8	4.1	4.5	4.3	0.1	2.3

Table VII cont.

Podiceps n. nigricollis

?	N	Min	Max	$\bar{x}$	SD	CV
a	13	65.3	75.3	71.0	3.0	4.2
b	13	11.4	12.5	12.0	0.4	3.3
c	14	11.8	13.3	12.6	0.5	4.0
d	12	7.1	8.2	7.5	0.3	4.0
e	13	2.5	3.1	2.8	0.2	7.1
f	13	4.0	4.8	4.3	0.2	4.7

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	70.3	70.5	72.7	73.3
b	11.8	12.3	12.3	12.8
c	13.1	13.2	13.2	13.4
d	7.2	7.5	7.8	7.9
e	2.7	2.8	2.9	3.0
f	4.3	4.4	4.4	4.5

Tachybaptus r. ruficollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a	9	52.5	57.5	54.4	1.7	3.1
b	9	8.6	9.8	9.1	0.4	4.4
c *	9	9.6	10.3	10.0	0.2	2.0
d	9	5.5	6.1	5.9	0.2	3.4
e	9	1.9	2.2	2.0	0.1	5.0
f	9	2.9	3.5	3.2	0.2	6.2

Tachybaptus r. ruficollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a	15	50.3	55.4	53.0	1.6	3.0
b	15	8.7	9.5	9.1	0.3	3.3
c *	15	9.2	10.2	9.7	0.3	3.1
d	15	5.4	6.1	5.7	0.2	3.5
e	15	1.8	2.2	2.0	0.1	5.0
f	15	2.9	3.5	3.1	0.1	3.2

Table VII cont.

Tachybaptus r. ruficollis

?	N	Min	Max	$\overline{x}$	SD	CV
a	22	48.8	56.0	53.1	1.9	3.6
b	22	8.1	9.7	9.0	0.4	4.4
c	22	9.0	10.7	9.7	0.5	5.2
d	23	5.2	6.2	5.7	0.2	3.5
e	23	1.9	2.3	2.1	0.1	4.8
f	23	2.9	3.4	3.1	0.1	3.2

Tachybaptus r. capensis (1 ♂, 7 ?)

	N	Min	Max	$\overline{x}$	SD	CV
a	8	49.7	55.0	52.5	2.1	4.0
b	8	8.3	9.6	9.0	0.5	5.6
c	8	8.6	10.1	9.4	0.5	5.3
d	4	5.4	5.7	5.6	0.2	3.6
e	8	1.9	2.2	2.0	0.1	5.0
f	8	2.8	3.3	3.1	0.2	6.5

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	54.0	57.1	58.4
b	9.4	9.6	9.8
c	9.9	10.0	10.7
d	5.9	5.9	6.0
e	2.0	2.1	2.3
f	3.5	3.6	3.6

Rollandia microptera (1 ♂)

	Measurements
a	70.5
b	11.9
c	13.3
d	6.9
e	2.4
f	4.0

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	55.8	57.0
b	9.4	9.6
c	9.6	9.9
d	6.2	6.3
e	2.2	2.3
f	3.2	3.6

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	47.2	48.4	51.6	
b	7.9	8.0	8.0	9.2
c	8.1	8.2	8.5	9.3
d	4.9	5.0	5.1	5.5
e	1.7	1.7	1.8	1.9
f	2.7	2.8	2.9	3.1

Table VII cont.

Podilymbus podiceps (1 ♂, 2 ♀♀, 1 ?)

	Measurements			
a	67.8	69.0	78.0	80.9
b	10.4	11.5	12.1	13.0
c	12.0	12.8	14.0	14.8
d	6.1	7.0	7.8	7.8
e	2.4	2.6	2.6	2.6
f	3.8	4.2	4.5	4.8

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	60.8	62.6
b	10.3	10.7
c	11.1	11.3
d	6.5	6.7
e	2.3	2.4
f	3.6	3.8

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	108.4	117.6
b	16.7	18.8
c	19.4	21.0
d	10.8	12.2
e	3.9	4.2
f	5.7	6.5

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	68.7	69.4	
b	11.8	12.7	13.1
c	11.9	13.1	13.6
d	7.3	7.8	
e	2.5	2.9	
f	4.0	4.4	

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	66.5
b	11.4
c	11.9
d	6.7
e	2.3
f	4.1

Podiceps gallardoi ? (1 ?)

	Measurements
a	79.5
b	14.2
c	14.5
d	9.0
e	3.3
f	5.2

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	117.8	120.5	124.5	125.3
b	18.6	18.8	19.7	20.5
c	20.5	21.1	21.4	22.3
d	11.2	11.5	11.8	12.2
e	3.8	3.9	4.5	4.6
f	5.6	6.0	6.3	6.8

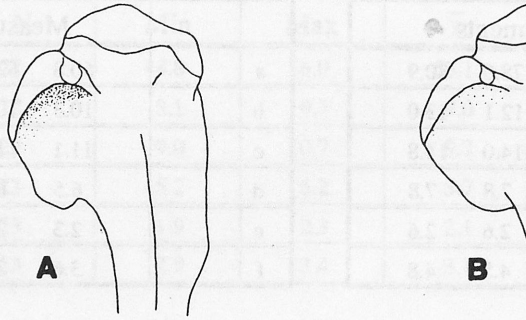

Fig. 36. Humerus 1: proximal part, caudal view. State A: The fossa pneumatica penetrates deeper under the tuberculum ventrale than in state B. As a result, the tuberculum ventrale forms a kind of eaves with a well-seen edge. State B: The fossa pneumatica is relatively shallow and open; its transition to the tuberculum ventrale is gradual.

Podiceps cristatus: B = 98%, N = 44
P. g. grisegena: B = 100%, N = 35
P. g. holboellii: B = 100%, N = 30
P. auritus: B = 100%, N = 17
P. nigricollis: B = 94%, N = 18
Tachybaptus ruficollis: A = 66%, N = 26

Rollandia rolland: B = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 2 spec., B = 1 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 3 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

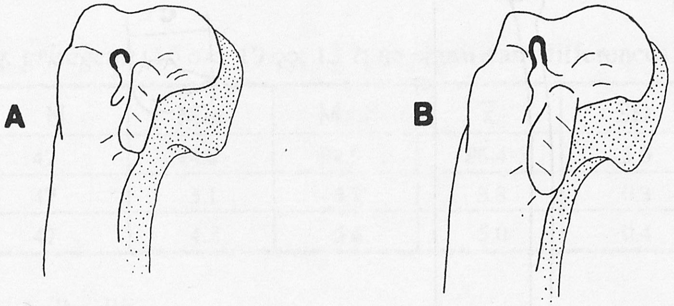

Fig. 37. Humerus 2: distal part, ventral view. Advisable magnification – min. 1x6.3; State A: There is only a small circular pit in the corner of the epicondylus ulnaris and condylus ulnaris. State B: An elongated groove separates the epicondylus ulnaris from the condylus ulnaris.

Podiceps cristatus: B = 83%, N = 47
P. g. grisegena: A = 91%, N = 35
P. g. holboellii: A = 87%, N = 30
P. auritus: uncharacteristic, N = 17
P. nigricollis: A = 94%, N = 17
Tachybaptus ruficollis: A = 79%, N = 28

Rollandia rolland: B = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: uncharacteristic, N = 3
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 2 spec., N = 3

8. RADIUS

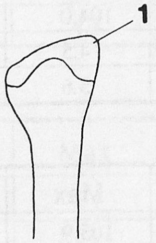

Fig. 38. Radius: nomenclature. Distal part, ventral view. 1 – Tuberculum mediale.

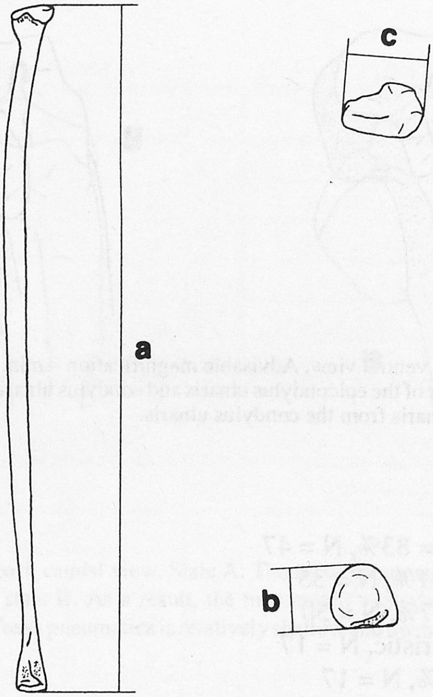

Fig. 39. Radius: measurements (ref. to Table VIII). a – Total length; b – Proximal width; c – Distal width, measured with the articular surface parallel to the axis of the calipers.

Table VIII

Radius (measured as in Fig. 39)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a *	32	90.9	106.3	98.8	3.4	3.4
b *	33	3.7	4.4	4.1	0.2	4.9
c	33	5.0	5.6	5.3	0.2	3.8

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a *	36	89.5	104.0	96.4	4.4	4.6
b *	36	3.5	4.5	4.0	0.2	5.0
c	36	4.6	5.6	5.2	0.2	3.8

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	21	89.9	105.9	97.7	3.9	4.0
b	22	3.7	4.4	4.1	0.2	4.9
c	22	4.7	5.8	5.3	0.3	5.7

Table VIII cont.

Podiceps g. grisegena (15 ♂♂, 19 ♀♀, 13 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	47	74.8	94.9	86.4	5.0	5.8
b	47	3.1	4.2	3.8	0.3	7.9
c	47	4.2	5.6	5.0	0.4	8.0

Podiceps g. holboellii

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	29	91.3	107.6	100.9	4.0	4.0
b **	29	4.1	4.8	4.4	0.2	4.5
c **	29	5.2	6.4	5.7	0.3	5.3

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	17	90.9	103.5	97.2	3.7	3.8
b **	17	3.9	4.5	4.2	0.2	4.8
c **	17	5.2	6.1	5.5	0.2	3.6

Podiceps g. holboellii

?	Measurements	
a	94.1	95.9
b	4.1	4.3
c	5.5	5.7

Podiceps a. auritus (8 ?, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	9	57.4	67.5	63.9	3.3	5.2
b	9	2.6	3.2	2.8	0.2	7.1
c	9	3.7	4.3	3.9	0.2	5.1

Podiceps a. arcticus (4 ♂♂, 3 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	7	64.2	72.7	68.1	2.8	4.1
b	7	2.9	3.3	3.1	0.2	6.5
c	7	3.8	4.4	4.1	0.2	4.9

Table VIII cont.

Podiceps auritus (*auritus* or *arcticus*; 1 ♀, 1 ?)

	Measurements	
a	63.6	63.7
b	2.8	2.9
c	3.7	3.8

Podiceps a. cornutus (1 ♂)

	Measurements
a	68.7
b	3.0
c	4.1

Podiceps n. nigricollis (14 ?, 2 ♂♂, 1 ♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	17	58.6	67.0	63.5	2.7	4.3
b	17	2.6	3.1	2.8	0.1	3.6
c	17	3.5	3.8	3.6	0.1	2.8

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	61.5	63.6	63.8	65.1
b	2.7	2.8	2.8	2.9
c	3.5	3.5	3.6	3.6

Tachybaptus r. ruficollis (9 ♂♂, 15 ♀♀, 23 ?; no significant differences between sexes)

	N	Min	Max	$\overline{x}$	SD	CV
a	47	42.7	49.8	46.4	1.7	3.7
b	47	1.8	2.3	2.1	0.1	4.8
c	47	2.6	3.2	2.8	0.1	3.6

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\overline{x}$	SD	CV
a	8	43.4	48.8	46.2	2.2	4.8
b	8	1.8	2.1	2.0	0.1	5.0
c	8	2.7	3.0	2.8	0.1	3.6

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	47.0	50.5	50.9
b	2.2	2.2	2.3
c	2.9	3.0	3.1

Rollandia microptera (1 ♂)

	Measurements
a	51.5
b	2.8
c	3.7

Table VIII cont.

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	51.0	51.1
b	2.2	2.3
c	3.0	3.1

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	44.7	45.2	46.7	48.9
b	1.7	1.9	2.0	2.0
c	2.5	2.6	2.9	2.9

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	62.4	63.0	71.9	72.2
b	2.3	2.5	2.6	2.8
c	3.5	3.5	4.0	4.0

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	54.5	56.8
b	2.2	2.3
c	3.1	3.3

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	93.5	99.2
b	4.1	4.4
c	5.4	5.7

Podiceps occipitalis (2 ♂♂)

	Measurements	
a	60.4	62.4
b	2.6	2.8
c	3.6	3.7

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	58.4
b	2.5
c	3.6

Podiceps gallardoi ? (1 ?)

	Measurements
a	70.4
b	3.0
c	4.1

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	103.0	104.7	108.7	109.5
b	4.1	4.3	4.5	4.6
c	5.2	5.5	5.5	5.8

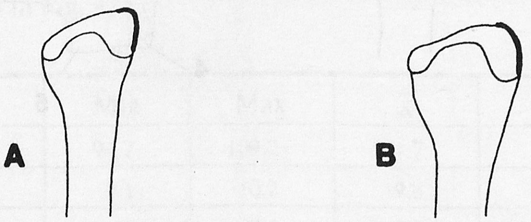

Fig. 40. Radius 1: distal part, ventral view. State A: The tuberculum mediale has a relatively narrow end. State B: The tuberculum mediale is broad and rounded.

Podiceps cristatus: B = 85%, N = 34
P. g. grisegena: B = 88%, N = 33
P. g. holboellii: B = 93%, N = 30
P. auritus: B = 94%, N = 16
P. nigricollis: B = 100%, N = 16
Tachybaptus ruficollis: A = 75%, N = 28

Rollandia rolland: B = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: uncharacteristic, N = 2
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

9. ULNA

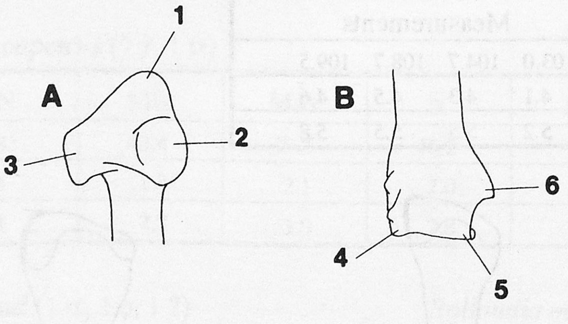

Fig. 41. Ulna: nomenclature. A – proximal part, medial view; B – distal part, dorsal view. 1 – Olecranon; 2 – Cotyla ventralis; 3 – Cotyla dorsalis; 4 – Condylus lateralis; 5 – Condylus medialis; 6 – Tuberculum carpale.

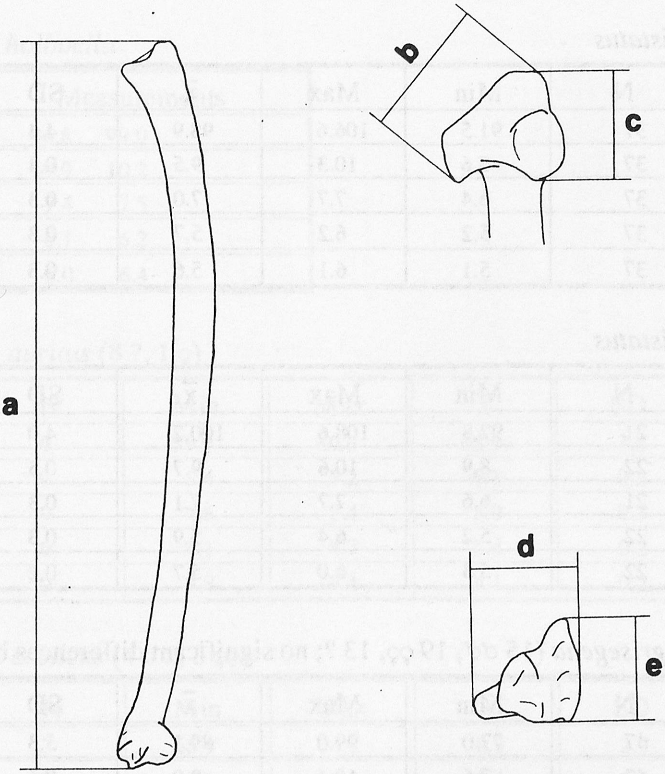

Fig. 42. Ulna: measurements (ref. to Table IX). a – Total length: distance from the olecranon to the crest of the condylus medialis; b – Maximum proximal width: distance from the olecranon to the tip of the cotyla dorsalis, measured with the articular surface parallel to the axis of the calipers; c – Proximal width: distance from the olecranon to the tip of the cotyla ventralis, measured with the articular surface parallel to the axis of the calipers; d – Distal width: distance from the condylus lateralis to the tip of the tuberculum carpale, measured with the condylus lateralis flat against the calipers; e – Distal thickness: the height of the condylus lateralis, measured with the dorsal tips of the crests of the condylus lateralis and condylus medialis flat against the calipers.

Table IX

Ulna (measured as in Fig. 42)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	33	94.7	109.2	101.7	3.1	3.0
b *	33	9.1	10.2	9.8	0.3	3.1
c *	33	6.5	7.5	7.2	0.2	2.8
d **	33	5.4	7.0	5.9	0.3	5.1
e	33	5.4	6.0	5.7	0.2	3.5

Table IX cont.

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	37	91.5	106.6	98.9	4.4	4.4
b *	37	8.6	10.3	9.5	0.4	4.2
c *	37	6.4	7.7	7.0	0.3	4.3
d **	37	5.2	6.2	5.7	0.3	5.3
e	37	5.1	6.1	5.6	0.3	5.4

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	21	92.8	108.6	100.2	4.0	4.0
b	22	8.9	10.6	9.7	0.5	5.2
c	21	6.6	7.7	7.1	0.3	4.2
d	22	5.2	6.4	5.9	0.3	5.1
e	22	5.3	6.0	5.7	0.2	3.5

Podiceps g. grisegena (15 ♂♂, 19 ♀♀, 13 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	47	77.0	99.0	89.1	5.3	5.9
b	47	7.6	10.4	9.0	0.6	6.7
c	47	5.9	7.5	6.7	0.4	6.0
d	47	4.7	6.4	5.7	0.4	7.0
e	47	4.6	6.1	5.3	0.4	7.5

Podiceps g. holboellii

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	29	93.8	110.7	103.7	4.0	3.9
b **	29	9.6	11.3	10.5	0.4	3.8
c *	29	7.3	8.6	7.8	0.3	3.8
d	29	5.3	7.3	6.4	0.4	6.2
e **	29	5.9	7.1	6.3	0.3	4.8

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	17	94.6	106.8	100.1	3.7	3.7
b **	17	9.6	10.8	10.2	0.3	2.9
c *	17	7.1	8.0	7.6	0.3	3.9
d	17	5.7	6.9	6.3	0.3	4.8
e **	17	5.6	6.4	6.1	0.2	3.3

Table IX cont.

Podiceps g. holboellii

?	Measurements	
a	96.8	99.0
b	9.9	10.2
c	7.4	7.5
d	6.1	6.2
e	6.0	6.4

Podiceps a. auritus (8 ?, 1 ♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	9	59.9	69.6	65.9	3.2	4.9
b	9	6.4	7.2	6.8	0.3	4.4
c	9	4.6	5.4	5.0	0.3	6.0
d	9	4.1	4.7	4.4	0.2	4.5
e	9	3.8	4.4	4.1	0.2	4.9

Podiceps a. arcticus (4 ♂♂, 3 ♀♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	7	65.9	74.7	70.3	2.9	4.1
b	7	7.0	7.8	7.4	0.3	4.1
c	7	5.0	5.7	5.4	0.2	3.7
d	7	4.3	5.0	4.7	0.3	6.4
e	7	4.0	4.6	4.3	0.2	4.7

Podiceps auritus (*auritus* or *arcticus*; 1 ♀, 1 ?)

	Measurements	
a	65.7	65.7
b	6.7	7.0
c	5.0	5.0
d	4.3	4.5
e	4.0	4.1

Podiceps a. cornutus (1 ♂)

	Measurements
a	70.4
b	7.2
c	5.2
d	4.6
e	4.3

Podiceps n. nigricollis (14 ?, 2 ♂♂, 1 ♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	17	60.3	69.2	65.2	2.7	4.1
b	17	5.9	7.1	6.4	0.3	4.7
c	17	4.4	5.2	4.7	0.2	4.3
d	17	4.0	4.6	4.3	0.2	4.7
e	17	3.6	4.2	3.9	0.2	5.1

Table IX cont.

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	63.4	65.0	65.7	66.8
b	6.1	6.5	6.6	6.7
c	4.7	4.9	4.9	4.9
d	4.3	4.4	4.4	4.4
e	4.0	4.0	4.2	4.2

Tachybaptus r. ruficollis (9 ♂♂, 15 ♀♀, 23 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	46	43.6	51.3	47.6	1.7	3.6
b	47	4.2	5.3	4.7	0.2	4.3
c	47	3.4	4.0	3.7	0.2	5.4
d	47	2.9	3.5	3.2	0.1	3.1
e	47	2.9	3.4	3.1	0.1	3.2

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	8	44.7	50.2	47.4	2.1	4.4
b	8	4.3	4.9	4.6	0.2	4.3
c	8	3.3	3.8	3.6	0.2	5.6
d	8	3.0	3.3	3.1	0.1	3.2
e	8	2.8	3.1	3.0	0.1	3.3

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	49.0	51.4	52.4
b	4.8	5.0	5.1
c	3.7	3.8	4.0
d	3.3	3.3	3.6
e	2.9	3.2	3.3

Rollandia microptera (1 ♂)

	Measurements
a	52.5
b	5.6
c	4.6
d	4.0
e	3.8

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	52.6	52.7
b	5.1	5.2
c	3.8	4.0
d	3.3	3.6
e	3.2	3.3

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	45.8	46.2	48.3	49.8
b	4.1	4.2	4.5	4.5
c	3.0	3.1	3.3	3.5
d	2.7	2.9	3.0	3.1
e	2.7	2.8	2.9	2.9

Table IX cont.

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	64.0	64.9	73.5	73.9
b	5.8	6.5	6.8	6.8
c	4.4	4.6	4.9	5.0
d	3.5	3.7	4.0	4.1
e	3.5	3.8	3.9	4.2

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	56.2	58.1
b	5.2	5.4
c	3.9	4.0
d	3.6	3.9
e	3.4	3.5

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	97.2	102.3
b	9.3	9.4
c	6.7	7.7
d	5.9	6.0
e	5.8	6.2

Podiceps occipitalis (2 ♂♂)

	Measurements	
a	62.4	64.3
b	6.1	6.7
c	4.7	5.1
d	4.0	4.3
e	3.7	4.2

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	59.5
b	5.9
c	4.7
d	3.9
e	3.7

Podiceps gallardoi ? (1 ?)

	Measurements
a	73.6
b	7.5
c	5.6
d	5.3
e	4.8

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	105.1	106.1	112.0	112.4
b	9.2	9.5	10.3	10.5
c	7.1	7.2	7.6	7.9
d	5.7	5.8	5.9	6.2
e	5.8	5.8	6.2	6.7

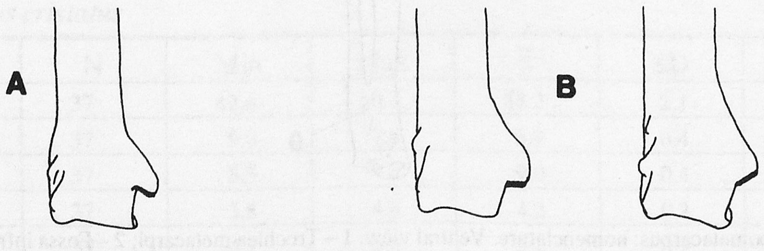

Fig. 43. Ulna 1: distal part, dorsal view. State A: The distal edge of the tuberculum carpale slants towards the distal part of the bone. State B: The distal edge of the tuberculum carpale is either at right angles to the bone axis or it slants towards the proximal part of the bone.

Podiceps cristatus: B = 89%, N = 37
P. g. grisegena: A = 71%, N = 34
P. g. holboellii: B = 70%, N = 30
P. auritus: B = 82%, N = 17
P. nigricollis: B = 88%, N = 17
Tachybaptus ruficollis: uncharacteristic, N = 28

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: uncharacteristic, N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

10. CARPOMETACARPUS

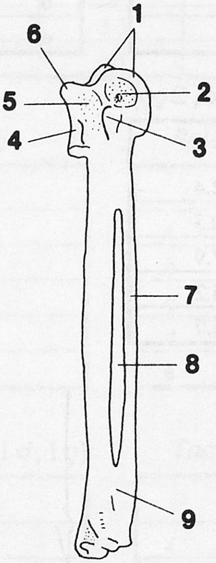

Fig. 44. Carpometacarpus: nomenclature. Ventral view. 1 – Trochlea metacarpi; 2 – Fossa infratrochlearis; 3 – Processus pisiformis; 4 – Os metacarpale I; 5 – Fovea carpalis cranialis; 6 – Tuberculum dorsale of the os metacarpale I; 7 – Os metacarpale III (and IV); 8 – Spatium intermetacarpale; 9 – Symphysis metacarpi distalis.

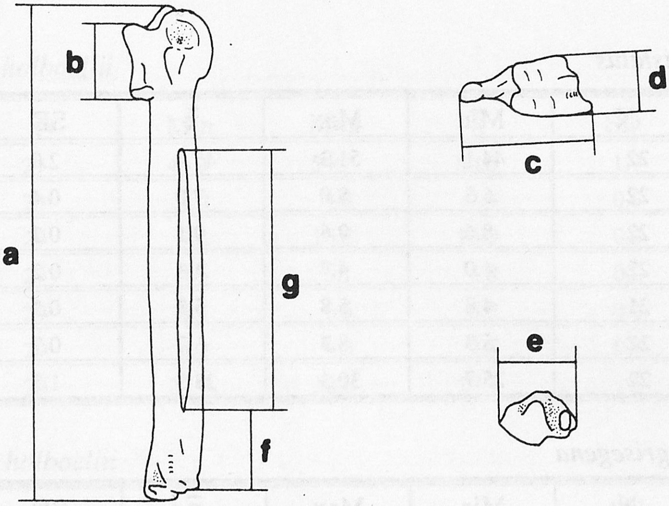

Fig. 45. Carpometacarpus: measurements (ref. to Table X). a – Total length; b – Length of the os metacarpale I; c – Proximal width: distance from the medial crest of the trochlea metacarpi to the tuberculum dorsale of the os metacarpale I; d – Proximal thickness, measured with the ventral surface flat against the calipers; e – Maximum distal width; f – Height of the symphysis metacarpica distalis: distance from the spatium intermetacarpale to the distal end of the os metacarpale III (and IV); g – Length of the spatium intermetacarpale.

Table X

Carpometacarpus (measured as in Fig. 45)

Podiceps cristatus

♂	N	Min	Max	x̄	SD	CV
a **	33	44.6	50.9	47.7	1.6	3.4
b *	32	6.5	7.6	7.1	0.3	4.2
c *	33	8.7	9.9	9.2	0.3	3.3
d **	33	4.1	4.7	4.4	0.2	4.5
e **	33	5.0	5.9	5.4	0.2	3.7
f	33	5.1	9.0	6.6	0.8	12.1
g **	33	26.2	31.7	29.0	1.4	4.8

Podiceps cristatus

♀	N	Min	Max	x̄	SD	CV
a **	37	42.6	50.3	46.2	2.1	4.5
b *	37	6.0	7.8	6.9	0.4	5.8
c *	37	8.3	9.8	9.0	0.4	4.4
d **	37	3.8	4.6	4.2	0.2	4.8
e **	37	4.7	5.6	5.2	0.2	3.8
f	37	5.0	8.4	6.4	0.7	10.9
g **	37	25.2	31.5	27.9	1.8	6.5

Table X cont.

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	22	44.1	51.3	47.0	2.0	4.3
b	22	6.5	8.0	7.0	0.4	5.7
c	22	8.6	9.6	9.1	0.3	3.3
d	22	4.0	4.7	4.3	0.2	4.7
e	21	4.8	5.8	5.3	0.3	5.7
f	22	5.3	8.3	6.7	0.7	10.4
g	22	25.7	30.3	28.3	1.3	4.6

Podiceps g. grisegena

♂	N	Min	Max	$\bar{x}$	SD	CV
a	15	40.3	47.7	44.3	2.0	4.5
b	15	6.4	7.9	7.1	0.5	7.0
c	15	8.0	9.4	8.8	0.4	4.5
d	15	3.3	4.6	4.1	0.3	7.3
e	15	4.7	5.6	5.2	0.2	3.8
f *	15	5.4	8.2	6.6	0.8	12.1
g	15	23.0	28.5	25.8	1.6	6.2

Podiceps g. grisegena

♀	N	Min	Max	$\bar{x}$	SD	CV
a	19	36.8	48.3	42.9	3.0	7.0
b	19	5.7	7.8	6.9	0.5	7.2
c	19	7.8	9.6	8.7	0.4	4.6
d	19	3.7	4.6	4.1	0.2	4.9
e	19	4.4	5.7	5.2	0.3	5.8
f *	19	4.9	7.7	6.0	0.8	13.3
g	19	22.0	29.3	25.5	1.9	7.5

Podiceps g. grisegena

?	N	Min	Max	$\bar{x}$	SD	CV
a	13	36.1	46.9	41.7	3.2	7.7
b	13	5.9	7.8	6.8	0.6	8.8
c	13	7.8	9.6	8.4	0.5	6.0
d	13	3.5	4.6	4.0	0.3	7.5
e	13	4.5	5.6	5.0	0.3	6.0
f	13	5.1	7.8	6.1	0.8	13.1
g	13	19.4	27.0	24.6	2.2	8.9

Table X cont.

Podiceps g. holboellii

♂	N	Min	Max	x̄	SD	CV
a **	29	46.3	54.7	50.6	1.9	3.8
b	29	7.0	9.0	7.9	0.5	6.3
c **	29	9.4	10.8	10.0	0.3	3.0
d **	29	4.5	5.1	4.8	0.2	4.2
e **	29	5.4	6.5	6.0	0.2	3.3
f	29	6.2	9.3	7.5	0.8	10.7
g **	29	27.0	32.0	29.7	1.5	5.1

Podiceps g. holboellii

♀	N	Min	Max	x̄	SD	CV
a **	17	45.0	50.4	48.0	1.8	3.8
b	17	6.7	9.0	7.8	0.6	7.7
c **	17	9.1	10.1	9.7	0.3	3.1
d **	17	4.3	5.2	4.6	0.2	4.3
e **	17	5.4	6.1	5.7	0.2	3.5
f	17	5.7	8.7	7.0	0.9	12.9
g **	17	25.4	31.6	28.1	1.9	6.8

Podiceps g. holboellii

?	Measurements	
a	46.4	46.7
b	7.3	7.6
c	9.6	9.8
d	4.5	4.5
e	5.9	5.9
f	6.0	6.3
g	27.6	28.2

Podiceps a. auritus (8 ?, 1 ♀)

	N	Min	Max	x̄	SD	CV
a	9	30.1	34.3	32.9	1.6	4.9
b	9	4.8	6.0	5.3	0.4	7.5
c	9	6.2	7.0	6.6	0.2	3.0
d	9	2.8	3.2	3.0	0.2	6.7
e	9	3.4	4.2	3.9	0.3	7.7
f	9	4.0	5.2	4.5	0.4	8.9
g	9	16.9	20.3	18.9	1.0	5.3

Table X cont.

Podiceps a. arcticus (4 ♂♂, 3 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	7	32.0	38.1	34.9	1.8	5.2
b	7	5.1	5.7	5.4	0.2	3.7
c	7	6.8	7.5	7.2	0.2	2.8
d	7	3.0	3.5	3.2	0.2	6.2
e	7	4.0	4.4	4.2	0.2	4.8
f	7	4.2	5.5	4.9	0.5	10.2
g	7	18.1	21.7	19.9	1.2	6.0

Podiceps auritus (*auritus* or *arcticus*; 1 ♀, 1 ?)

	Measurements	
a	31.7	32.7
b	4.6	5.3
c	6.4	
d	3.0	3.1
e	3.8	4.1
f	4.3	4.8
g	17.9	19.0

Podiceps a. cornutus (1 ♂)

	Measurements
a	33.8
b	5.2
c	7.1
d	3.1
e	4.1
f	4.5
g	20.2

Podiceps n. nigricollis (14 ?, 2 ♂♂, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	17	29.0	33.6	31.6	1.6	5.1
b	16	4.2	5.3	4.9	0.3	6.1
c	16	6.0	6.9	6.4	0.3	4.7
d	17	2.8	3.2	3.0	0.1	3.3
e	17	3.2	4.2	3.7	0.2	5.4
f	17	3.7	5.0	4.3	0.3	7.0
g	17	16.6	20.1	18.6	1.0	5.4

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	31.2	32.1	32.5	32.8
b	4.5	5.0	5.0	5.5
c	6.4	6.5	6.6	6.6
d	3.0	3.1	3.1	3.2
e	3.7	3.8	3.9	3.9
f	4.3	4.6	4.7	5.1
g	16.7	18.7	18.8	18.9

Table X cont.

Tachybaptus r. ruficollis (9 ♂♂, 15 ♀♀, 23 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	46	21.6	25.5	23.8	1.0	4.2
b	46	3.1	3.8	3.4	0.2	5.9
c	46	4.6	5.3	5.0	0.2	4.0
d	47	2.1	2.5	2.3	0.1	4.3
e	46	2.6	3.2	2.8	0.1	3.6
f	46	3.0	4.3	3.7	0.3	8.1
g	46	12.0	15.0	13.4	0.7	5.2

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	8	22.1	24.9	23.6	0.9	3.8
b	8	3.1	3.8	3.5	0.3	8.6
c	8	4.7	5.1	4.9	0.1	2.0
d	8	2.1	2.4	2.2	0.1	4.5
e	8	2.7	2.9	2.8	0.1	3.6
f	8	3.3	4.1	3.6	0.2	5.6
g	8	12.4	14.5	13.5	0.7	5.2

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	25.1	26.3	26.8
b	3.7	3.8	4.1
c	5.1	5.2	5.2
d	2.4	2.4	2.5
e	3.0	3.0	3.1
f	3.2	3.2	3.5
g	14.6	15.6	16.6

Rollandia microptera (1 ♂)

	Measurements
a	28.1
b	4.3
c	6.7
d	3.1
e	4.0
f	4.4
g	14.9

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	24.7	26.0
b	4.0	4.5
c	5.2	5.5
d	2.5	2.7
e	3.0	3.1
f	3.5	3.7
g	13.9	15.2

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	20.8	20.9	21.3	22.8
b	2.9	3.0	3.1	3.5
c	4.4	4.6	4.8	4.9
d	2.2	2.2	2.2	2.3
e	2.5	2.5	2.7	2.9
f	3.0	3.0	3.1	3.3
g	11.7	11.8	11.9	12.4

Table X cont.

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	30.4	31.5	35.0	36.1
b	4.0	4.5	4.6	4.8
c	5.5	5.8	6.4	6.6
d	2.7	2.8	2.9	3.0
e	3.2	3.5	3.5	3.8
f	4.5	5.3	5.4	5.7
g	17.5	18.8	20.7	21.0

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	27.5	28.9
b	4.0	4.2
c	5.6	5.7
d	2.6	2.7
e	3.3	3.4
f	3.1	3.3
g	16.5	17.8

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	47.9	51.2
b	7.3	7.4
c	9.1	9.9
d	4.4	4.6
e	5.4	5.5
f	7.2	7.3
g	26.0	29.5

Podiceps occipitalis (2 ♂♂)

	Measurements	
a	31.0	32.0
b	4.7	5.0
c	6.4	7.0
d	3.1	3.2
e	3.8	3.9
f	4.5	5.0
g	18.1	18.2

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	28.5
b	4.9
c	6.1
d	3.0
e	3.5
f	4.1
g	15.8

Podiceps gallardoi ? (1 ?)

	Measurements
a	36.8
b	5.8
c	7.6
d	3.8
e	4.4
f	4.3
g	21.1

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	50.0	51.0	51.6	53.6
b	7.2	7.5	8.0	8.4
c	9.4	9.6	9.8	10.2
d	4.2	4.6	4.7	4.7
e	5.1	5.2	5.5	5.6
f	7.8	7.9	8.0	8.1
g	28.3	28.6	31.3	33.3

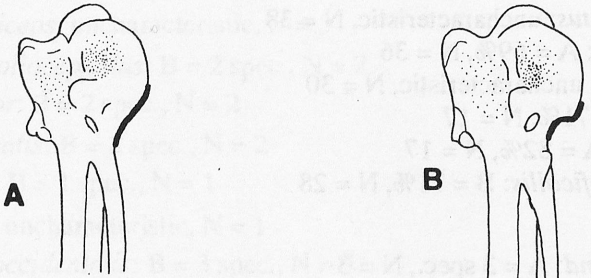

Fig. 46. Carpometacarpus 1: proximal part, ventral view. State A: The joint between the trochlea metacarpi and the os metacarpale III (and IV) curves gently. State B: The joint between the trochlea metacarpi and the os metacarpale III (and IV) is angular.

Podiceps cristatus: B = 89%, N = 38
P. g. grisegena: uncharacteristic, N = 36
P. g. holboellii: A = 83%, N = 30
P. auritus: uncharacteristic, N = 17
P. nigricollis: uncharacteristic, N = 17
Tachybaptus ruficollis: A = 89%, N = 28

Rollandia rolland: A = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 2 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: uncharacteristic, N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

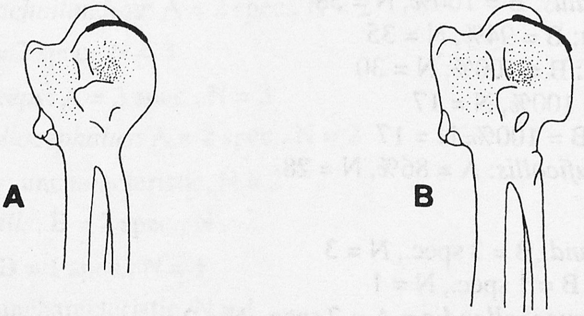

Fig. 47. Carpometacarpus 2: proximal part, ventral view. State A: The upper part of the trochlea metacarpi is rounded. State B: The upper part of the trochlea metacarpi is flattened.

Podiceps cristatus: uncharacteristic, N = 38
P. g. grisegena: A = 69%, N = 36
P. g. holboellii: uncharacteristic, N = 30
P. auritus: B = 71%, N = 17
P. nigricollis: A = 82%, N = 17
Tachybaptus ruficollis: B = 71%, N = 28

Rollandia rolland: A = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: uncharacteristic, N = 3
Podilymbus podiceps: uncharacteristic, N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

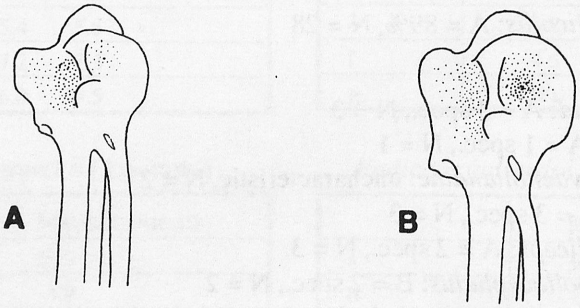

Fig. 48. Carpometacarpus 3: poximal part, ventral view. State A: The fossa infratrochlearis is relatively shallow (shallower than the fovea carpalis cranialis). State B: The fossa infratrochlearis is relatively deep (equal in depth to or deeper than the fovea carpalis cranialis).

Podiceps cristatus: B = 100%, N = 38
P. g. grisegena: B = 94%, N = 35
P. g. holboellii: B = 100%, N = 30
P. auritus: B = 100%, N = 17
P. nigricollis: B = 100%, N = 17
Tachybaptus ruficollis: A = 86%, N = 28

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3

Podilymbus podiceps: uncharacteristic, N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): uncharacteristic, N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

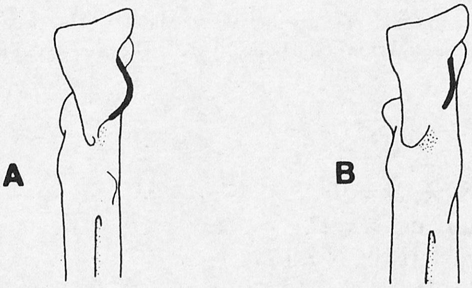

Fig. 49. Carpometacarpus 4: proximal part, medial view. State A: The dorsal edge of the trochlea metacarpi is characteristically bulging. State B: The dorsal edge of the trochlea metacarpi is more or less straight.

Podiceps cristatus: B = 92%, N = 38
P. g. grisegena: A = 80%, N = 35
P. g. holboellii: A = 87%, N = 31
P. auritus: B = 88%, N = 17
P. nigricollis: B = 94%, N = 17
Tachybaptus ruficollis: A = 100%, N = 28

Rollandia rolland: A = 2 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): uncharacteristic, N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

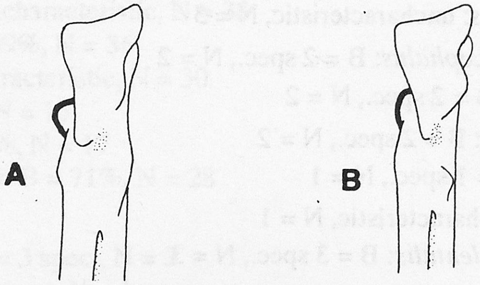

Fig. 50. Carpometacarpus 5: proximal part, medial view. State A: The processus pisiformis is long and protrudes distinctly from the ventral side of the bone. State B: The processus pisiformis is short and rounded.

Podiceps cristatus: A = 87%, N = 38
P. g. grisegena: B = 77%, N = 35
P. g. holboellii: B = 87%, N = 30
P. auritus: uncharacteristic, N = 18
P. nigricollis: uncharacteristic, N = 17
Tachybaptus ruficollis: B = 93%, N = 28

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: A = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: uncharacteristic, N = 3

11. PHALANX DIGITI MAJORIS I

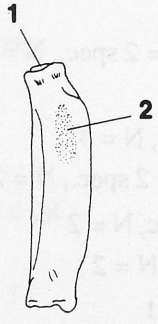

Fig. 51. Phalanx digiti majoris I: nomenclature. Ventral view. 1 – Facies articularis articulationis metacarpophalangeae; 2 – Fossa phalangea.

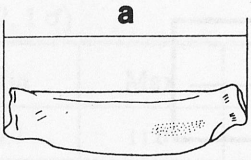

Fig. 52. Phalanx digiti majoris I: measurements (ref. to Table XI). a – Total length, measured with the bone parallel to the axis of the calipers.

Table XI

Phalanx digiti majoris I (measured as in Fig. 52)

Podiceps cristatus

♂	N	Min	Max	x̄	SD	CV
a *	33	18.8	21.5	20.4	0.8	3.9

Podiceps cristatus

♀	N	Min	Max	x̄	SD	CV
a *	36	18.4	21.9	19.8	0.9	4.5

Podiceps cristatus

?	N	Min	Max	x̄	SD	CV
a	21	17.6	22.2	20.1	1.0	5.0

Podiceps g. grisegena (14 bb, 19 aa, 12 ?; no significant differences between sexes)

	N	Min	Max	x̄	SD	CV
a	45	16.0	21.2	18.8	1.3	6.9

Podiceps g. holboellii

♂	N	Min	Max	x̄	SD	CV
a *	29	19.6	23.0	21.5	1.0	4.7

Podiceps g. holboellii

♀	N	Min	Max	x̄	SD	CV
a *	17	19.1	22.6	20.8	1.1	5.3

Table XI cont.

Podiceps g. holboellii

?	Measurements	
a	20.4	20.7

Podiceps a. auritus (8 ?, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	9	13.0	14.6	14.0	0.6	4.3

Podiceps a. arcticus (4 ♂♂, 3 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	7	14.0	15.8	14.6	0.8	5.5

Podiceps auritus (*auritus* or *arcticus*; 1 ♀, 1 ?)

	Measurements	
a	13.3	13.7

Podiceps a. cornutus (1 ♂)

	Measurements
a	15.2

Podiceps n. nigricollis (12 ?, 2 ♂♂, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	15	12.5	14.8	13.5	0.7	5.2

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	13.8	13.9	14.0	14.1

Tachybaptus r. ruficollis (9 ♂♂, 15 ♀♀, 22 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	46	9.3	11.3	10.3	0.5	4.9

Table XI cont.

Tachybaptus r. capensis (6 ?, 1 ♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	7	9.7	11.0	10.3	0.5	4.9

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements
a	11.1 11.1 11.1

Rollandia microptera (1 ♂)

	Measurements
a	12.4

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements
a	10.8 11.6

Tachybaptus dominicus (1 ♂, 1 ♀, 1 ?)

	Measurements
a	9.2 9.5 9.5

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements
a	12.8 14.1 14.2 15.6

Poliocephalus poliocephalus (1 ?)

	Measurements
a	11.8

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements
a	19.6 21.8

Podiceps occipitalis (2 ♂♂)

	Measurements
a	13.0 14.0

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	12.1

Podiceps gallardoi ? (1 ?)

	Measurements
a	15.3

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements
a	21.3 21.3 22.9 23.5

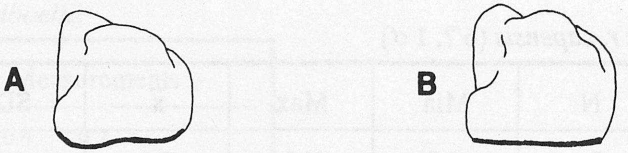

Fig. 53. Phalanx digiti majoris I 1: facies articularis articulationis metacarpophalangeae. State A: The caudal edge of the facies articularis articulationis metacarpophalangeae is wavy. State B: The caudal edge of the facies articularis articulationis metacarpophalangeae is straight.

Podiceps cristatus: B = 74%, N = 34
P. g. grisegena: uncharacteristic, N = 33
P. g. holboellii: uncharacteristic, N = 30
P. auritus: uncharacteristic, N = 16
P. nigricollis: A = 87%, N = 16
Tachybaptus ruficollis: A = 75%, N = 28

Rollandia rolland: uncharacteristic, N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: A = 1 spec., N = 1
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

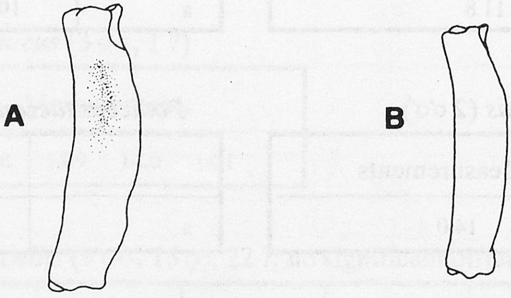

Fig. 54. Phalanx digiti majoris I 2: ventral view. State A: The fossa phalangea, an extensive depression (with one or two smaller but deeper depressions), is present. State B: The fossa phalangea is either absent or very shallow and scarcely visible. There are no small and deep depressions in it.

Podiceps cristatus: A = 94%, N = 34
P. g. grisegena: A = 91%, N = 33
P. g. holboellii: uncharacteristic, N = 30
P. auritus: A = 75%, N = 16
P. nigricollis: A = 100%, N = 16
Tachybaptus ruficollis: B = 79%, N = 28

Rollandia rolland: A = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: B = 2 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 1 spec.
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: uncharacteristic, N = 3

12. PELVIS

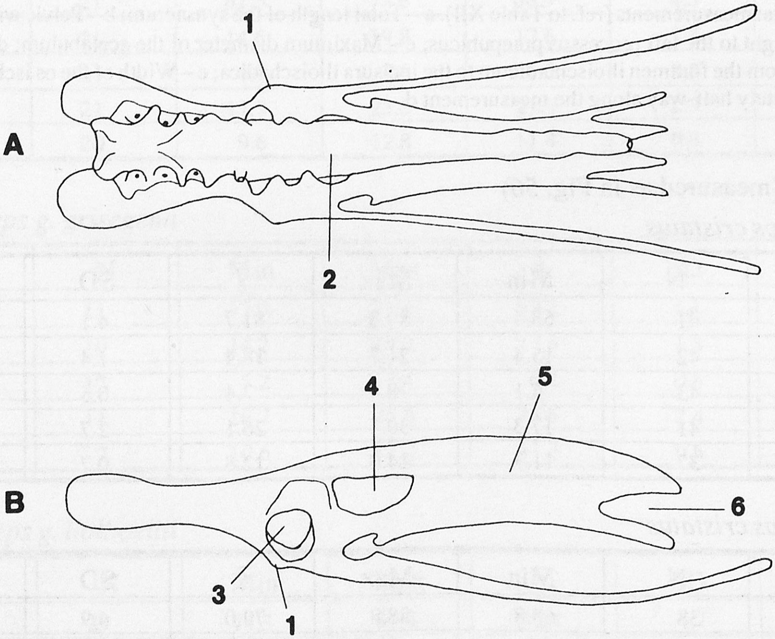

Fig. 55. Pelvis: nomenclature. A – ventral view; B – lateral view. 1 – Processus praepubicus; 2 – Synsacrum; 3 – Acetabulum; 4 – Foramen ilioischiadicum; 5 – Os ischii; 6 – Incisura ilioischadica.

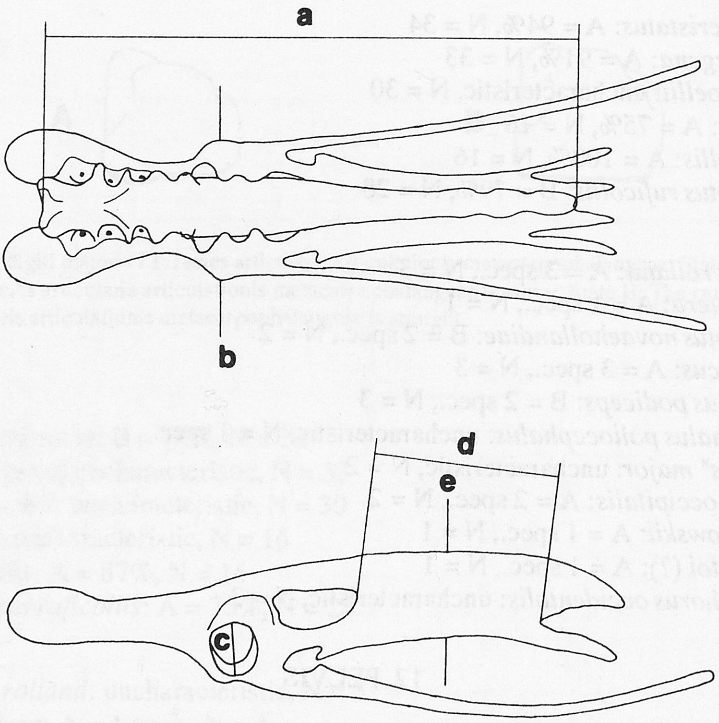

Fig. 56. Pelvis: measurements (ref. to Table XII). a – Total length of the synsacrum; b – Pelvis width: distance from the right to the left processus praepubicus; c – Maximum diameter of the acetabulum; d – Minimum distance from the foramen ilioischiadicum to the incisura ilioischadica; e – Width of the os ischii, measured approximately half-way along the measurement d.

Table XII

Pelvis (measured as in Fig. 56)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a *	41	68.4	89.3	81.7	4.1	5.0
b	42	15.4	21.7	18.4	1.4	7.6
c **	43	6.1	8.4	7.4	0.6	8.1
d	41	17.3	30.4	26.1	2.7	10.3
e *	37	11.3	14.0	12.8	0.7	5.5

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a *	38	68.8	88.8	79.0	4.9	6.2
b	38	15.6	20.3	17.8	1.1	6.2
c **	39	5.5	8.5	6.9	0.6	8.7
d	37	21.2	31.1	25.8	2.2	8.5
e *	33	11.1	14.7	12.4	0.8	6.5

Table XII cont.

Podiceps cristatus

?	N	Min	Max	$\overline{x}$	SD	CV
a	21	72.7	85.9	79.2	3.8	4.8
b	14	16.2	20.8	18.6	1.3	7.0
c	22	5.8	8.2	7.1	0.6	8.5
d	21	20.7	28.6	25.7	1.9	7.4
e	14	11.5	14.1	12.6	0.7	5.6

Podiceps g. grisegena

♂	N	Min	Max	$\overline{x}$	SD	CV
a	16	65.0	79.1	72.0	4.4	6.1
b	17	16.4	19.6	17.7	1.0	5.6
c **	18	5.2	8.6	6.9	0.9	13.0
d	17	19.9	26.4	23.0	1.9	8.3
e	17	9.8	12.2	11.2	0.7	6.2

Podiceps g. grisegena

♀	N	Min	Max	$\overline{x}$	SD	CV
a	21	62.3	75.8	68.9	4.3	6.2
b	21	14.6	19.8	17.6	1.4	8.0
c **	21	4.9	7.6	6.0	0.8	13.3
d	21	17.3	25.3	21.5	2.3	10.7
e	20	9.6	12.8	11.4	0.8	7.0

Podiceps g. grisegena

?	N	Min	Max	$\overline{x}$	SD	CV
a	11	57.0	71.6	67.2	4.1	6.1
b	10	14.2	19.2	17.5	1.5	8.6
c	12	5.2	7.4	6.2	0.6	9.7
d	11	18.7	25.8	21.8	2.4	11.0
e	7	10.6	12.2	11.3	0.6	5.3

Podiceps g. holboellii

♂	N	Min	Max	$\overline{x}$	SD	CV
a **	29	74.3	91.6	82.4	4.7	5.7
b	28	17.3	21.6	19.3	1.3	6.7
c *	29	6.2	9.7	7.8	0.9	11.5
d	29	21.4	31.5	25.5	2.4	9.4
e	28	10.4	14.0	12.5	0.8	6.4

Table XII cont.

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	17	72.2	82.9	78.8	3.2	4.1
b	17	17.7	19.7	18.8	0.6	3.2
c *	17	5.9	8.9	7.1	0.9	12.7
d	17	20.3	29.2	24.4	2.1	8.6
e	17	11.1	15.5	12.6	1.1	8.7

Podiceps g. holboellii

?	Measurements	
a	77.0	82.7
b	19.5	
c	7.2	7.4
d	24.0	24.9
e	11.3	

Podiceps a. auritus (9 ?, 3 ♂♂, 2 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	13	49.2	56.0	53.6	1.8	3.4
b	12	13.0	15.4	13.8	0.7	5.1
c	14	4.0	6.2	4.9	0.6	12.2
d	13	12.8	18.9	15.9	1.7	10.7
e	11	7.9	10.4	8.8	0.8	9.1

Podiceps a. arcticus (6 ♂♂, 4 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	9	50.9	57.7	54.7	2.8	5.1
b	10	13.9	15.4	14.7	0.6	4.1
c	10	4.6	6.0	5.2	0.5	9.6
d	10	15.3	19.3	17.1	1.1	6.4
e	9	8.8	9.9	9.3	0.4	4.3

Podiceps auritus (*auritus* or *arcticus*; 2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	49.1	53.5	53.7	53.9
b	12.8	13.4	13.9	14.0
c	4.7	5.0	5.1	5.1
d	13.5	13.6	15.4	15.5
e	8.4	8.7	9.5	

Podiceps a. cornutus (1 ♂)

	Measurements
a	52.9
b	13.9
c	5.1
d	17.1
e	8.5

Table XII cont.

Podiceps n. nigricollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a	8	45.1	51.0	47.8	2.3	4.8
b	8	13.8	15.8	14.8	0.7	4.7
c *	8	5.3	6.4	5.7	0.3	5.3
d *	8	13.8	16.2	14.9	1.0	6.7
e	7	9.0	10.3	9.4	0.5	5.3

Podiceps n. nigricollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a	7	42.8	48.8	46.3	2.1	4.5
b	8	14.1	15.4	14.8	0.4	2.7
c *	9	4.5	5.7	5.1	0.5	9.8
d *	8	12.4	14.6	13.6	0.9	6.6
e	8	7.8	10.2	9.0	0.9	10.0

Podiceps n. nigricollis

?	N	Min	Max	$\bar{x}$	SD	CV
a	12	44.5	53.2	47.7	2.6	5.5
b	8	13.3	15.6	14.4	0.9	6.2
c	14	4.9	6.3	5.4	0.4	7.4
d	12	12.8	16.4	14.3	1.0	7.0
e	9	7.9	9.9	9.2	0.6	6.5

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	44.6	48.4	48.5	49.3
b	14.5	15.4	16.0	17.0
c	4.9	5.1	5.2	5.5
d	13.2	13.5	15.3	15.4
e	9.2	9.4	9.4	9.6

Tachybaptus r. ruficollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a *	9	37.5	42.9	40.1	1.8	4.5
b	9	11.5	12.8	12.2	0.4	3.3
c	9	3.9	4.5	4.2	0.2	4.8
d	9	11.0	14.8	12.6	1.1	8.7
e	9	9.6	11.6	10.3	0.6	5.8

Table XII cont.

Tachybaptus r. ruficollis

♀	N	Min	Max	$\overline{x}$	SD	CV
a *	18	35.2	41.6	38.6	1.7	4.4
b	18	10.9	13.6	12.1	0.7	5.8
c	18	3.7	4.8	4.1	0.3	7.3
d	18	10.2	13.6	12.2	1.1	9.0
e	17	10.1	11.4	10.6	0.4	3.8

Tachybaptus r. ruficollis

?	N	Min	Max	$\overline{x}$	SD	CV
a	23	35.7	42.2	38.7	1.8	4.7
b	21	11.0	13.2	12.0	0.6	5.0
c	25	3.5	5.0	4.2	0.4	9.5
d	25	10.7	14.1	12.1	0.9	7.4
e	23	9.9	11.3	10.4	0.4	3.8

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\overline{x}$	SD	CV
a	8	36.3	41.2	39.4	1.8	4.6
b	3	10.6	12.5	–	–	–
c	8	3.4	4.7	4.2	0.4	9.5
d	6	10.7	13.5	12.5	1.0	8.0
e	2	8.9	9.5	–	–	–

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	37.8	41.3	42.4
b	11.7	12.9	14.3
c	3.9	4.4	4.6
d	13.8	15.3	15.4
e	9.0	9.1	9.3

Rollandia microptera (1 ♂)

	Measurements
a	63.4
b	17.6
c	7.2
d	24.3
e	14.9

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	37.4	39.6
b	10.8	11.5
c	4.0	4.6
d	10.6	11.4
e	9.6	10.2

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	32.2	34.3	35.5	35.6
b	10.3	10.7	12.2	
c	3.3	3.4	3.7	3.7
d	9.6	10.0	10.4	11.2
e	8.0	8.3	9.0	

Table XII cont.

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	50.0	51.6	57.0	58.1
b	13.2	14.1		
c	5.0	5.2	5.6	5.8
d	14.6	15.1	19.4	
e	10.2	10.7		

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	41.9	44.8
b	13.0	13.5
c	4.4	5.3
d	10.4	11.2
e	10.0	10.4

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	78.6	87.1
b	17.9	20.0
c	7.0	8.1
d	27.2	32.8
e	14.1	14.3

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	41.0	42.0	42.1
b	16.0	16.3	16.6
c	4.7	5.7	6.1
d	12.4	12.5	13.7
e	9.7	9.7	11.0

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	44.1
b	17.0
c	5.6
d	13.7
e	10.2

Podiceps gallardoi ? (1 ?)

	Measurements
a	48.5
b	17.3
c	6.1
d	14.4
e	10.9

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	79.8	86.9	93.2	
b	17.2	17.7	19.7	19.8
c	6.8	7.0	7.1	7.6
d	26.7	31.4	31.7	32.2
e	13.5	13.8	13.9	

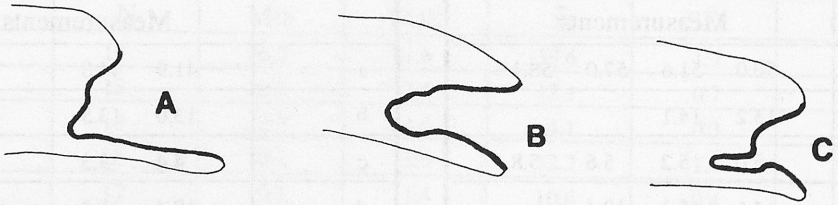

Fig. 57. Pelvis 1: caudal part of the os ischii, lateral view. State A: The incisura ilioischadica is broad, rather shallow and usually (but not always) S-shaped. The upper caudal part of the os ischii is short and stocky. State B: The incisura ilioischadica may be either narrow or broad but it cuts deep into the os ischii. The upper caudal part of the os ischii forms an elongated strip. State C: The incisura ilioischadica is of a distinctive shape: its upper part is broad and shallow, while the lower part is narrow and cuts deep into the os ischii. The upper caudal part of the os ischii is short and stocky.

Podiceps cristatus: B = 94%, N = 47
P. g. grisegena: B = 97%, N = 37
P. g. holboellii: B = 100%, N = 31
P. auritus: B = 100%, N = 19
P. nigricollis: B = 100%, N = 22
Tachybaptus ruficollis: A = 100%, N = 35

Rollandia rolland: A = 2 spec., N = 2
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: C = 2 spec., N = 2
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 3 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

13. FEMUR

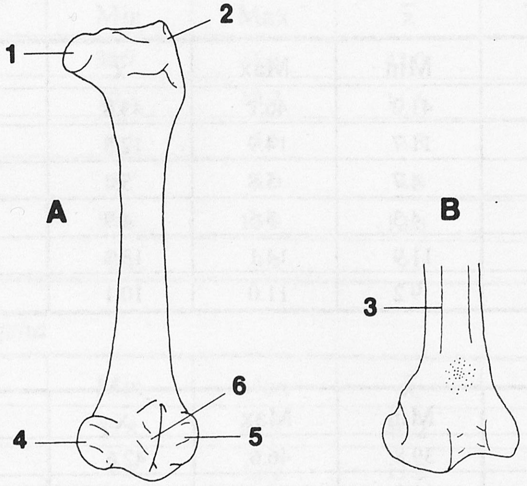

Fig. 58. Femur: nomenclature. A – caudal view; B – distal part, cranial view. 1 – Caput femoralis; 2 – Trochanter major; 3 – Linea trochanterica cranialis; 4 – Condylus medialis; 5 – Condylus lateralis, fibular part; 6 – Condylus lateralis, tibial part.

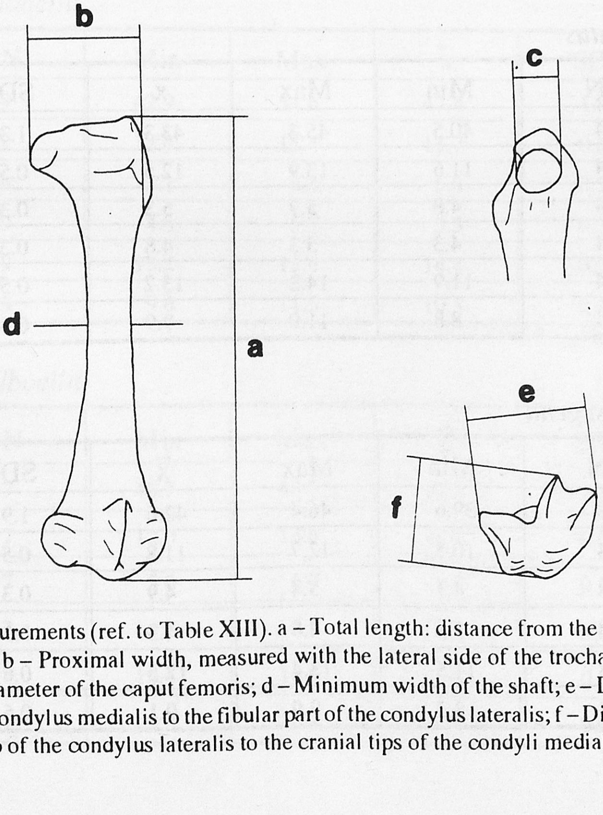

Fig. 59. Femur: measurements (ref. to Table XIII). a – Total length: distance from the trochanter major to the condylus lateralis; b – Proximal width, measured with the lateral side of the trochanter major flat against the calipers; c – Diameter of the caput femoris; d – Minimum width of the shaft; e – Distal width: maximum distance from the condylus medialis to the fibular part of the condylus lateralis; f – Distal thickness: distance from the caudal tip of the condylus lateralis to the cranial tips of the condyli medialis and lateralis.

Table XIII

Femur (measured as in Fig. 59)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	43	41.2	46.2	43.8	1.2	2.7
b **	43	11.7	14.9	12.8	0.5	3.9
c **	43	4.7	5.8	5.4	0.3	5.6
d *	43	4.3	5.5	4.9	0.3	6.1
e **	43	11.9	14.1	13.3	0.6	4.5
f **	43	9.2	11.0	10.1	0.4	4.0

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	40	39.8	46.6	42.6	1.7	4.0
b **	40	11.0	13.6	12.3	0.6	4.9
c **	40	4.4	5.6	5.1	0.3	5.9
d *	40	4.1	5.3	4.8	0.3	6.2
e **	40	11.6	14.2	12.8	0.6	4.7
f **	39	8.8	10.8	9.7	0.5	5.2

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	24	40.5	45.3	43.3	1.3	3.0
b	24	11.6	13.9	12.5	0.5	4.0
c	24	4.8	5.7	5.3	0.3	5.7
d	24	4.3	5.3	4.8	0.3	6.2
e	24	11.9	14.2	13.2	0.5	3.8
f	24	8.8	11.0	9.9	0.6	6.1

Podiceps g. grisegena

♂	N	Min	Max	$\bar{x}$	SD	CV
a	18	39.6	46.4	42.6	1.9	4.5
b	18	10.5	12.7	11.8	0.5	4.2
c	18	4.1	5.4	4.9	0.3	6.1
d	18	3.8	4.8	4.3	0.3	7.0
e *	18	11.5	13.4	12.5	0.6	4.8
f	18	8.3	9.9	9.1	0.5	5.5

Table XIII cont.

Podiceps g. grisegena

♀	N	Min	Max	$\overline{x}$	SD	CV
a	21	38.7	46.3	42.0	2.4	5.7
b	21	10.3	13.7	11.6	0.9	7.8
c	21	4.1	5.6	4.8	0.3	6.2
d	21	3.7	5.0	4.3	0.4	9.3
e *	21	10.5	13.9	12.0	0.9	7.5
f	21	8.1	9.9	9.0	0.5	5.6

Podiceps g. grisegena

?	N	Min	Max	$\overline{x}$	SD	CV
a	15	35.8	44.2	40.2	2.6	6.5
b	15	9.8	12.6	11.2	0.7	6.2
c	15	4.3	5.2	4.7	0.3	6.4
d	15	3.8	4.7	4.2	0.3	7.1
e	15	10.6	12.6	11.6	0.5	4.3
f	15	7.8	9.7	8.8	0.5	5.7

Podiceps g. holboellii

♂	N	Min	Max	$\overline{x}$	SD	CV
a *	29	42.9	51.6	47.4	1.8	3.8
b **	29	12.6	15.4	13.7	0.6	4.4
c **	29	5.1	6.4	5.8	0.3	5.2
d **	29	4.8	5.7	5.3	0.2	3.8
e **	29	13.2	15.6	14.4	0.5	3.5
f **	29	9.6	11.5	10.5	0.4	3.8

Podiceps g. holboellii

♀	N	Min	Max	$\overline{x}$	SD	CV
a *	17	43.7	48.5	46.2	1.5	3.2
b **	17	12.0	13.6	12.9	0.5	3.9
c **	17	5.0	6.0	5.5	0.3	5.5
d **	17	4.8	5.3	5.1	0.2	3.9
e **	17	12.4	14.6	13.6	0.5	3.7
f **	17	9.0	10.8	10.0	0.5	5.0

Table XIII cont.

Podiceps g. holboellii

?	Measurements	
a	44.2	45.8
b	12.5	13.4
c	5.3	5.9
d	4.7	5.1
e	13.7	13.9
f	10.4	10.4

Podiceps a. auritus (9 ?, 3 ♂♂, 2 ♀♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	14	29.9	34.3	32.1	1.5	4.7
b	14	8.1	9.9	9.0	0.6	6.7
c	14	3.4	4.2	3.8	0.3	7.9
d	14	3.0	3.9	3.4	0.3	8.8
e	13	8.6	10.6	9.6	0.6	6.2
f	12	6.4	7.8	7.1	0.5	7.0

Podiceps a. arcticus (6 ♂♂, 3 ♀♀)

	N	Min	Max	$\overline{x}$	SD	CV
a	9	32.3	36.2	34.0	1.4	4.1
b	9	9.2	10.7	9.8	0.4	4.1
c	9	3.8	4.6	4.1	0.2	4.9
d	9	3.6	4.0	3.8	0.2	5.3
e	9	9.3	10.7	10.2	0.5	4.9
f	9	7.0	8.0	7.5	0.3	4.0

Podiceps auritus (*auritus* or *arcticus*; 2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	30.4	30.9	32.2	33.5
b	8.8	8.8	9.4	9.6
c	3.6	3.8	3.9	4.4
d	3.5	3.5	3.6	3.7
e	9.1	9.4	9.8	10.1
f	6.8	6.9	7.4	7.5

Podiceps a. cornutus (1 ♂)

	Measurements
a	33.3
b	9.6
c	3.9
d	3.5
e	10.0
f	7.4

Table XIII cont.

Podiceps n. nigricollis

♂	N	Min	Max	$\overline{x}$	SD	CV
a **	8	32.5	35.4	33.8	1.2	3.6
b **	8	8.4	9.2	8.8	0.3	3.4
c **	8	3.7	4.2	3.9	0.2	5.1
d **	8	3.0	3.4	3.2	0.2	6.2
e **	7	8.8	9.6	9.1	0.3	3.3
f **	7	6.4	7.1	6.7	0.2	3.0

Podiceps n. nigricollis

♀	N	Min	Max	$\overline{x}$	SD	CV
a **	9	30.8	33.0	32.1	0.8	2.5
b **	9	7.8	8.7	8.2	0.3	3.7
c **	9	3.4	3.8	3.6	0.1	2.8
d **	9	2.7	3.2	3.0	0.2	6.7
e **	9	8.0	8.9	8.5	0.3	3.5
f **	9	5.8	6.4	6.2	0.2	3.2

Podiceps n. nigricollis

?	N	Min	Max	$\overline{x}$	SD	CV
a	15	30.5	35.4	32.7	1.4	4.3
b	15	7.9	9.1	8.4	0.4	4.8
c	15	3.4	4.2	3.7	0.2	5.4
d	15	2.9	3.4	3.1	0.1	3.2
e	15	8.3	9.8	8.8	0.4	4.5
f	15	6.0	7.3	6.4	0.4	6.2

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	32.5	33.0	33.8	34.3
b	8.6	8.8	8.9	9.1
c	3.8	3.9	3.9	4.1
d	3.1	3.2	3.4	3.5
e	8.7	8.8	8.8	9.3
f	6.4	6.5	6.6	6.8

Table XIII cont.

Tachybaptus r. ruficollis

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	9	30.6	32.6	31.5	0.8	2.5
b	9	7.2	7.9	7.6	0.2	2.6
c	9	3.0	3.5	3.3	0.2	6.1
d	9	2.4	2.7	2.6	0.1	3.8
e	9	7.4	8.1	7.9	0.2	2.5
f *	9	5.5	6.2	5.9	0.3	5.1

Tachybaptus r. ruficollis

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	18	28.5	32.8	30.3	1.0	3.3
b	18	7.1	8.0	7.5	0.2	2.7
c	18	3.0	3.4	3.2	0.1	3.1
d	18	2.3	2.8	2.6	0.1	3.8
e	18	7.4	8.3	7.8	0.2	2.6
f *	18	5.3	6.1	5.7	0.2	3.5

Tachybaptus r. ruficollis

?	N	Min	Max	$\bar{x}$	SD	CV
a	24	28.3	32.6	30.7	1.1	3.6
b	25	6.9	8.5	7.5	0.3	4.0
c	25	2.8	3.5	3.2	0.2	6.2
d	25	2.2	2.7	2.6	0.1	3.8
e	23	7.3	8.5	7.8	0.3	3.8
f	24	5.3	6.3	5.7	0.3	5.3

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	8	27.6	31.6	30.0	1.3	4.3
b	8	6.8	7.8	7.3	0.4	5.5
c	8	2.8	3.4	3.2	0.2	6.2
d	8	2.3	2.8	2.6	0.2	7.7
e	8	7.0	8.5	7.7	0.5	6.5
f	8	5.2	6.2	5.6	0.3	5.4

Table XIII cont.

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	31.9	33.5	33.7
b	7.7	7.8	7.9
c	3.2	3.3	3.7
d	2.7	2.8	2.9
e	7.8	8.1	8.6
f	5.6	6.1	6.2

Rollandia microptera (1 ♂)

	Measurements
a	44.4
b	12.6
c	5.4
d	4.8
e	12.5
f	9.1

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	29.9	30.1
b	7.2	7.6
c	3.2	3.4
d	2.6	2.7
e	7.4	7.6
f	5.5	5.7

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	24.9	27.0	27.7	28.0
b	6.1	6.3	6.6	7.0
c	2.6	2.6	2.8	3.0
d	2.4	2.5	2.5	2.6
e	6.6	6.7	7.1	7.2
f	4.7	4.9	5.1	5.2

Podilymbus podiceps (2 ♀♀, 1 ♂, 1 ?)

	Measurements			
a	36.0	36.0	39.5	42.1
b	8.1	8.7	9.0	9.7
c	3.6	4.0	4.0	4.2
d	2.9	3.2	3.3	3.5
e	8.4	8.7	9.5	9.6
f	6.3	6.7	7.2	7.2

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	29.7	30.7
b	7.8	8.1
c	3.3	3.4
d	3.0	3.1
e	8.1	8.5
f	5.6	5.9

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	44.7	48.7
b	13.3	14.2
c	5.2	5.9
d	5.7	5.9
e	14.2	15.3
f	10.0	10.4

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	33.1	35.4	35.6
b	8.2	8.5	9.1
c	3.9	4.0	4.3
d	3.2	3.4	3.5
e	8.8	9.2	9.5
f	6.8	6.8	6.9

Table XIII cont.

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	34.9
b	9.2
c	4.4
d	3.3
e	9.4
f	6.7

Podiceps gallardoi ? (1 ?)

	Measurements
a	38.9
b	10.2
c	4.6
d	3.8
e	10.6
f	7.5

Aechmophorus occidentalis (2♂♂, 2♀♀)

	Measurements			
a	45.5	46.8	47.3	47.7
b	13.9	14.0	14.1	15.0
c	5.5	5.6	5.8	6.2
d	4.9	5.4	5.5	5.6
e	14.8	15.2	15.4	15.6
f	10.8	11.2	11.7	11.8

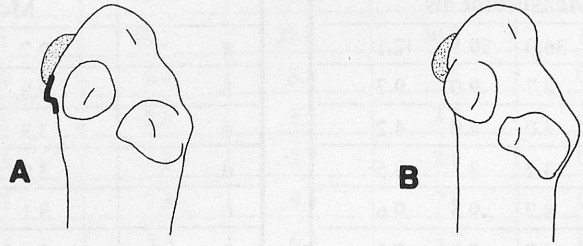

Fig. 60. Femur 1: proximal part, lateral view. State A: A bulge on the caudal side is visible. State B: Caudal side is hidden behind a round depression on the lateral side.

Podiceps cristatus: A = 94%, N = 53
P. g. grisegena: B = 81%, N = 42
P. g. holboellii: B = 74%, N = 31
P. auritus: A = 89%, N = 19
P. nigricollis: uncharacteristic, N = 22
Tachybaptus ruficollis: uncharacteristic, N = 31

Rollandia rolland: uncharacteristic, N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

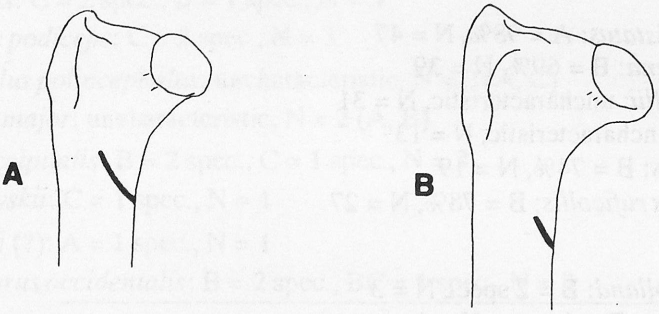

Fig. 61. Femur 2: proximal part, cranial view. State A: A faint line reaches approximately up to the mid-line of the shaft. State B: A faint line is shorter than in state A; it is visible only on the right (i.e. medial) edge of the shaft.

Podiceps cristatus: B = 90%, N = 48
P. g. grisegena: A = 95%, N = 40
P. g. holboellii: A = 87%, N = 31
P. auritus: uncharacteristic, N = 20
P. nigricollis: uncharacteristic, N = 25
Tachybaptus ruficollis: B = 68%, N = 31

Rollandia rolland: B = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: uncharacteristic, N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: A = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

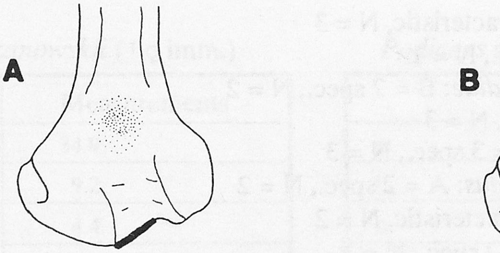

Fig. 62. Femur 3: distal part, cranial view. State A: The medial edge of the condylus lateralis is straight and relatively long. State B: The medial edge of the condylus lateralis is rounded and relatively short.

Podiceps cristatus: A = 98%, N = 47
P. g. grisegena: B = 69%, N = 39
P. g. holboellii: uncharacteristic, N = 31
P. auritus: uncharacteristic, N = 13
P. nigricollis: B = 74%, N = 19
Tachybaptus ruficollis: B = 78%, N = 27

Rollandia rolland: B = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: uncharacteristic, N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: A = 2 spec., N = 2
Podiceps occipitalis: uncharacteristic, N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

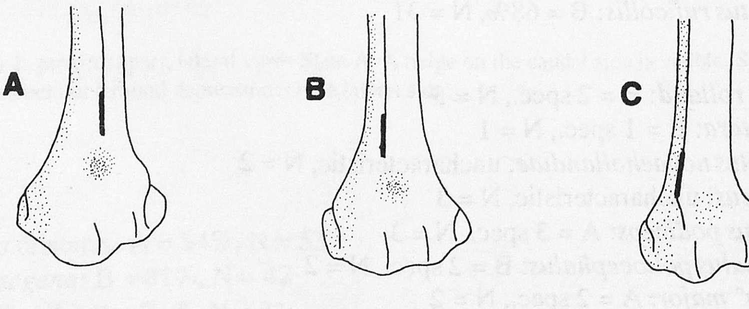

Fig. 63. Femur 4: distal part, cranial view. State A: In the distal part of the bone the linea trochanterica cranialis is in the middle of the shaft or even on its right side. State B: In the distal part of the bone the linea trochanterica cranialis is on the left side of the shaft. State C: In the distal part of the bone the linea trochanterica cranialis is on the left edge of the shaft. Sometimes it is poorly-seen.

Podiceps cristatus: uncharacteristic, N = 43 (A, B, C)
P. *g. grisegena*: uncharacteristic, N = 62 (A, B, C)
P. g. holboellii: A = 73%, B = 6 spec., C = 2 spec., N = 30
P. auritus: A = 100%, N = 20
P. nigricollis: B = 71%, A = 7 spec., N = 24
Tachybaptus ruficollis: C = 97%, BC = 1 spec., N = 35

Rollandia rolland: C = 3 spec., N = 3
R. microptera: C = 1 spec., N = 1
Tachybaptus novaehollandiae: C = 2 spec., N = 2
T. dominicus: C = 2 spec., B = 1 spec., N = 3
Podilymbus podiceps: C = 3 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2 (A, C)
"*Podiceps*" *major*: uncharacteristic, N = 2 (A, B)
Podiceps occipitalis: B = 2 spec., C = 1 spec., N = 3
P. taczanowskii: C = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: B = 2 spec., BC = 1 spec., N = 3

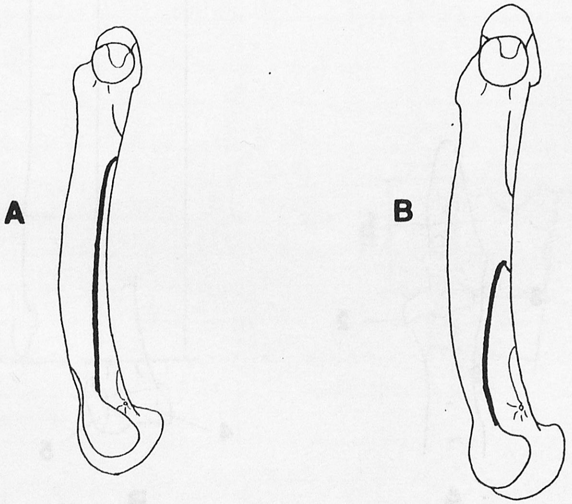

Fig. 64. Femur 5: medial view. State A: A distinct line runs from the condylus medialis towards the proximal part of the bone, ending approximately at three-quarters of the shaft length. State B: A distinct line runs from the condylus medialis towards the proximal part of the bone, ending approximately half-way along the shaft.

Podiceps cristatus: B = 100%, N = 49
P. g. grisegena: B = 78%, N = 40
P. g. holboellii: B = 94%, N = 31

P. auritus: B = 100%, N = 20
P. nigricollis: B = 92%, N = 24
Tachybaptus ruficollis: A = 100%, N = 35

Rollandia rolland: A = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 3 spec., N = 3
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

14. TIBIOTARSUS

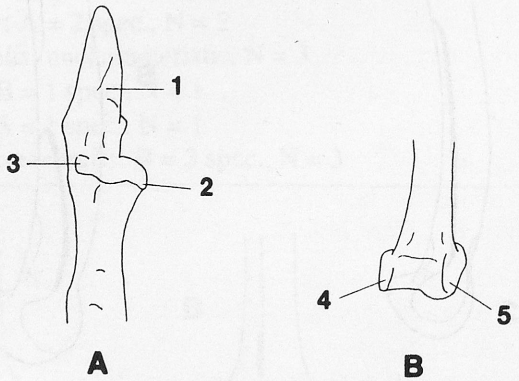

Fig. 65. Tibiotarsus: nomenclature. A – proximal part, caudal view; B – distal part, caudal view. 1 – Processus cnemialis; 2 – Margo cnemialis lateralis; 3 – Margo cnemialis medialis; 4 – Condylus distalis medialis; 5 – Condylus distalis lateralis.

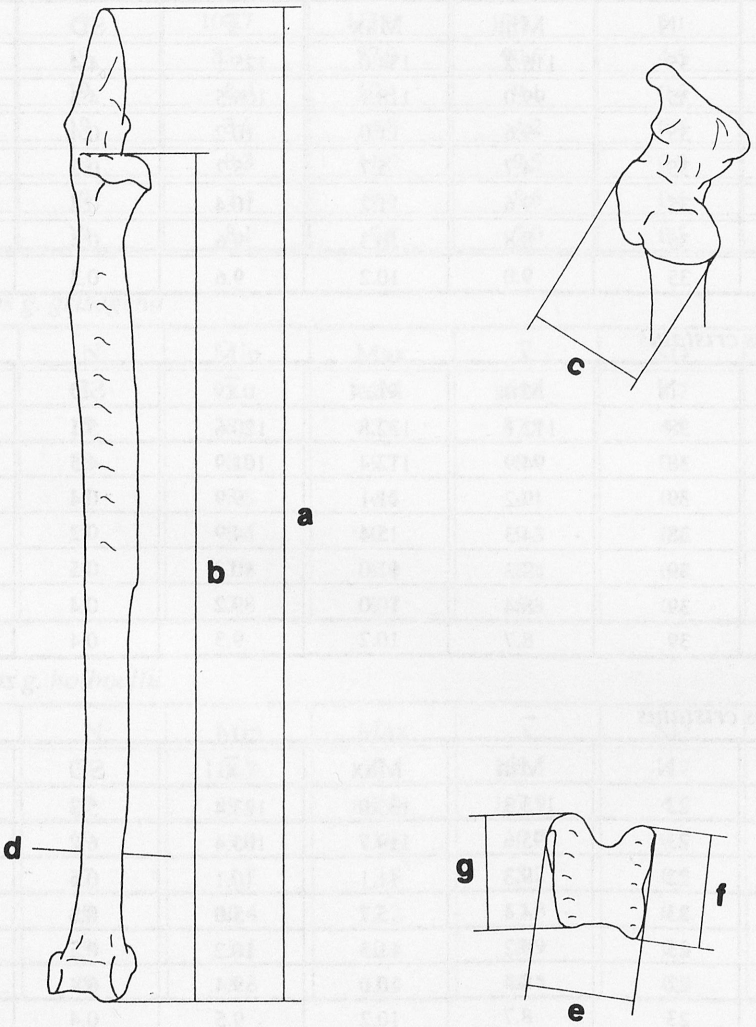

Fig. 66. Tibiotarsus: measurements (ref. to Table XIV). a – Total length: maximum distance from the tip of the processus cnemialis to the condylus distalis lateralis, measured with the shaft parallel to the axis of the calipers; b – Length without the processus cnemialis: distance from the margo cnemialis medialis (at the junction with the processus cnemialis) to the condylus distalis lateralis, measured with the shaft parallel to the axis of the calipers; c – Proximal width: maximum distance from the margo cnemialis medialis to the margo cnemialis lateralis, measured with the articular surface parallel to the axis of the calipers; d – Minimum width of the shaft; e – Distal width: distance from the condylus distalis medialis to the condylus distalis lateralis, measured with the condylus distalis medialis flat against the calipers; f – Height of the condylus distalis medialis; g – Height of the condylus distalis lateralis.

Table XIV

Tibiotarsus (measured as in Fig. 66)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	35	116.2	134.0	125.1	4.4	3.5
b **	35	99.0	118.1	106.5	4.3	4.0
c **	35	9.6	11.0	10.2	0.4	3.9
d **	35	4.7	5.7	5.2	0.2	3.8
e *	35	9.6	11.2	10.4	0.4	3.8
f **	35	8.8	10.3	9.6	0.4	4.2
g **	35	9.0	10.2	9.6	0.3	3.1

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	38	112.1	132.8	120.6	5.1	4.2
b **	38	94.9	112.4	101.9	4.5	4.4
c **	39	9.2	11.1	9.9	0.4	4.0
d **	38	4.3	5.4	4.9	0.2	4.1
e *	39	9.3	11.0	10.2	0.5	4.9
f **	39	8.4	10.0	9.2	0.4	4.3
g **	39	8.7	10.2	9.3	0.4	4.3

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	23	113.3	133.0	123.4	5.3	4.3
b	23	95.6	119.7	105.4	6.2	5.9
c	22	9.3	11.1	10.1	0.5	5.0
d	23	4.4	5.7	5.0	0.3	6.0
e	23	9.2	11.3	10.2	0.5	4.9
f	22	8.4	10.0	9.4	0.4	4.3
g	23	8.7	10.2	9.5	0.4	4.2

Podiceps g. grisegena

♂	N	Min	Max	$\bar{x}$	SD	CV
a *	15	104.1	118.8	112.4	4.7	4.2
b *	15	85.6	99.4	93.9	4.3	4.6
c	15	8.9	10.1	9.4	0.4	4.3
d	15	4.0	4.9	4.4	0.3	6.8
e	15	8.9	10.9	9.9	0.6	6.1
f	15	7.9	9.4	8.8	0.4	4.5
g	15	8.6	10.0	9.3	0.4	4.3

Table XIV cont.

Podiceps g. grisegena

♀	N	Min	Max	$\bar{x}$	SD	CV
a *	19	100.7	115.9	108.1	5.1	4.7
b *	19	83.1	97.0	90.6	4.5	5.0
c	19	8.0	10.4	9.1	0.6	6.6
d	19	3.6	4.8	4.2	0.4	9.5
e	19	8.3	11.0	9.5	0.8	8.4
f	19	7.4	9.6	8.6	0.6	7.0
g	19	8.1	9.9	9.0	0.5	5.6

Podiceps g. grisegena

?	N	Min	Max	$\bar{x}$	SD	CV
a	14	95.0	112.9	104.7	5.7	5.4
b	15	78.9	95.6	87.9	4.9	5.6
c	15	8.2	9.7	8.9	0.4	4.5
d	15	3.8	4.6	4.1	0.3	7.3
e	15	8.4	10.1	9.3	0.5	5.4
f	15	7.8	9.0	8.4	0.4	4.8
g	15	7.8	9.7	8.8	0.5	5.7

Podiceps g. holboellii

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	27	118.7	137.6	128.3	4.7	3.7
b **	27	99.4	118.9	107.9	4.7	4.4
c **	29	9.9	11.8	10.7	0.4	3.7
d	27	4.7	5.8	5.2	0.3	5.8
e **	29	10.4	12.2	11.3	0.4	3.5
f *	29	9.1	10.4	9.9	0.3	3.0
g *	29	9.8	11.4	10.6	0.3	2.8

Podiceps g. holboellii

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	17	114.8	131.5	123.4	5.1	4.1
b **	17	97.6	109.4	103.8	4.2	4.0
c **	17	9.2	10.9	10.2	0.4	3.9
d	17	4.7	5.7	5.1	0.3	5.9
e **	17	9.6	11.7	10.8	0.5	4.6
f *	17	8.8	10.1	9.7	0.4	4.1
g *	17	9.7	10.8	10.3	0.4	3.9

Table XIV cont.

Podiceps g. holboellii

?	Measurements	
a	121.2	123.7
b	102.8	104.0
c	9.9	10.5
d	4.8	5.4
e	10.2	11.1
f	8.9	9.8
g	10.0	10.3

Podiceps a. auritus (9 ?, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	9	80.0	91.6	84.8	4.5	5.3
b	9	65.7	76.0	70.5	3.9	5.5
c	10	6.7	7.6	7.1	0.3	4.2
d	9	2.8	3.5	3.1	0.2	6.5
e	9	6.6	7.8	7.1	0.4	5.6
f	9	6.2	6.9	6.5	0.2	3.1
g	9	6.5	7.8	6.9	0.4	5.8

Podiceps a. arcticus (5 ♂♂, 3 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	7	86.4	96.6	90.2	3.9	4.3
b	7	72.4	80.2	74.9	3.4	4.5
c	8	7.4	8.1	7.8	0.3	3.8
d	7	3.4	3.9	3.6	0.2	5.6
e	7	7.5	8.7	8.1	0.4	4.9
f	7	6.3	7.2	6.8	0.3	4.4
g	7	7.0	7.6	7.3	0.2	2.7

Podiceps auritus (*auritus* or *arcticus*; 1 ♂, 1 ♀, 1 ?)

	Measurements		
a	81.5	84.1	
b	67.2	70.0	
c	7.0	7.1	7.4
d	3.0	3.3	
e	7.6	7.7	
f	6.4	6.5	
g	6.9	6.9	

Podiceps a. cornutus (1 ♂)

	Measurements
a	88.5
b	74.4
c	7.5
d	3.6
e	7.7
f	6.6
g	7.0

Table XIV cont.

Podiceps n. nigricollis (15 ?, 3 ♂♂, 3 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	16	76.7	86.9	81.2	3.6	4.4
b	17	64.4	73.4	68.3	3.1	4.5
c	21	6.4	7.4	6.9	0.3	4.3
d	17	2.8	3.4	3.0	0.2	6.7
e	16	6.3	7.5	6.9	0.3	4.3
f	16	5.9	6.7	6.3	0.2	3.2
g	17	6.3	7.1	6.6	0.2	3.0

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	80.9	82.7	84.7	86.9
b	67.1	70.3	70.8	72.8
c	6.6	6.9	7.1	7.1
d	2.7	3.0	3.0	3.2
e	6.9	6.9	7.3	7.4
f	6.2	6.4	6.4	6.5
g	6.5	6.7	6.7	6.8

Tachybaptus r. ruficollis (9 ♂♂, 16 ♀♀, 23 ?; no significant differences between sexes)

	N	Min	Max	$\bar{x}$	SD	CV
a	47	60.4	70.6	66.0	2.2	3.3
b	48	51.5	61.6	56.5	1.9	3.4
c	48	5.4	6.2	5.8	0.2	3.4
d	48	2.5	3.0	2.7	0.1	3.7
e	48	5.4	6.6	6.0	0.3	5.0
f	48	5.1	6.0	5.5	0.2	3.6
g	48	5.0	5.8	5.4	0.2	3.7

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\bar{x}$	SD	CV
a	8	59.0	67.1	64.5	2.7	4.2
b	8	50.6	57.5	55.1	2.3	4.2
c	8	5.3	6.3	5.7	0.4	7.0
d	8	2.5	3.0	2.8	0.2	7.1
e	8	5.6	6.3	5.8	0.2	3.4
f	8	5.1	5.7	5.5	0.2	3.6
g	8	5.0	6.3	5.4	0.4	7.4

Table XIV cont.

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	66.5	68.9	70.6
b	55.8	59.0	60.6
c	5.7	6.3	6.5
d	2.5	2.6	2.6
e	6.0	6.2	6.3
f	5.6	5.9	5.9
g	5.6	5.9	5.9

Rollandia microptera (1 ♂)

	Measurements
a	105.6
b	91.5
c	9.2
d	4.5
e	9.2
f	8.6
g	8.8

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	65.6	67.7
b	55.8	57.1
c	5.9	6.1
d	2.7	3.0
e	5.7	6.1
f	5.8	6.0
g	5.5	5.8

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	54.2	57.6	60.2	60.7
b	46.9	49.4	51.6	51.9
c	5.0	5.2	5.2	5.3
d	2.3	2.5	2.6	
e	5.0	5.2	5.5	5.6
f	4.5	4.7	5.2	5.4
g	4.7	4.8	5.1	5.2

Podilymbus podiceps (2 ♀♀, 2 ?, 1 ♂)

	Measurements				
a	72.0	74.4	83.7	88.2	
b	62.5	64.3	72.4	76.0	
c	6.3	6.6	7.0	7.2	
d	3.2	3.2	3.6	3.7	
e	6.6	7.0	7.5	7.7	8.0
f	6.2	6.5	6.6	7.3	7.3
g	5.8	6.3	6.6	7.0	7.5

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	69.7	71.4
b	59.4	60.5
c	6.1	6.3
d	2.7	2.8
e	5.9	6.1
f	5.6	6.0
g	5.6	5.7

"*Podiceps*" *major* (1 ♀, 1 ?)

	Measurements	
a	125.0	139.1
b	108.2	119.2
c	11.0	11.4
d	5.6	6.1
e	11.1	12.5
f	9.5	10.5
g	9.7	10.6

Podiceps occipitalis (2 ♂♂, 1 ?)

	Measurements		
a	78.9	79.9	
b	67.7	68.4	
c	7.0	7.5	7.6
d	3.2		
e	7.1	7.4	
f	6.5	6.6	
g	6.6	6.7	

Table XIV cont.

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	83.1
b	71.4
c	7.3
d	3.2
e	7.2
f	6.8
g	7.1

Podiceps gallardoi ? (1 ?)

	Measurements
a	91.7
b	77.9
c	8.6
d	3.4
e	8.1
f	7.6
g	8.1

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	141.0	143.7	145.5	147.5
b	118.0	124.0	124.2	124.4
c	10.9	11.2	11.3	11.6
d	5.6	5.6	5.9	6.0
e	11.8	12.1	12.4	12.7
f	10.5	10.7	10.9	11.5
g	11.1	11.2	11.8	11.9

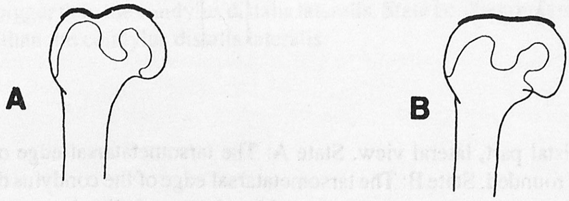

Fig. 67. Tibiotarsus 1: distal part, medial view. State A: The tarsometatarsal edge of the condylus distalis medialis has a relatively deep, distinct, U-shaped depression. State B: The tarsometatarsal edge of the condylus distalis medialis is either flat or has a very shallow, broad depression.

Podiceps cristatus: A = 98%, N = 45

P. g. grisegena: A = 100%, N = 37

P. g. holboellii: A = 100%, N = 30

P. auritus: A = 100%, N = 18

P. nigricollis: A = 100%, N = 21
Tachybaptus ruficollis: B = 88%., N = 32

Rollandia rolland: B = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: B = 3 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic. N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: A = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: A = 3 spec., N = 3

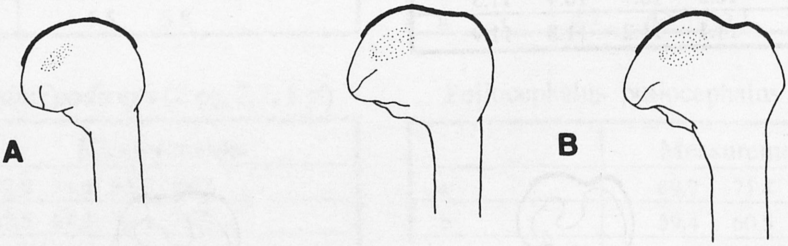

Fig. 68. Tibiotarsus 2: distal part, lateral view. State A: The tarsometatarsal edge of the condylus distalis lateralis is more or less rounded. State B: The tarsometatarsal edge of the condylus distalis lateralis is wavy and consists of two parts separated by a depression (either deep or shallow).

Podiceps cristatus: B = 92%, N = 51
P. g. grisegena: B = 95%, N = 40
P. g. holboellii: B = 100%, N = 31
P. auritus: B = 100%, N = 18
P. nigricollis: B = 100%, N = 21
Tachybaptus ruficollis: A = 100%, N = 32

Rollandia rolland: A = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1

Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" major: A = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

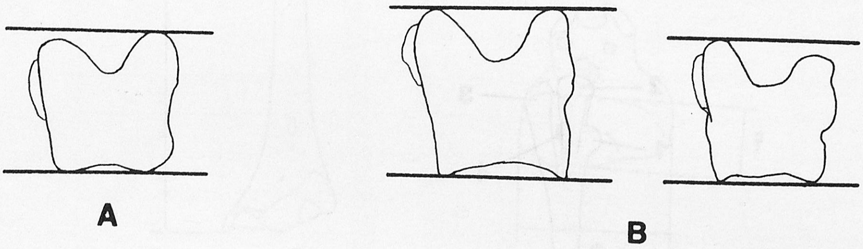

Fig. 69. Tibiotarsus 3: distal part, distal view. The character is best visible when the caudal crests of the condylus distalis lateralis and condylus distalis medialis are flat against the calipers. State A: The condylus distalis medialis is bigger than the condylus distalis lateralis. State B: The condylus distalis medialis is either equal to or smaller than the condylus distalis lateralis.

Podiceps cristatus: B = 78%, N = 50
P. g. grisegena: B = 95%, N = 42
P. g. holboellii: B = 100%, N = 31
P. auritus: B = 100%, N = 18
P. nigricollis: B = 95%, N = 20
Tachybaptus ruficollis: A = 100%, N = 32

Rollandia rolland: A = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3

Podilymbus podiceps: B = 2 spec., N = 3
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

15. TARSOMETATARSUS

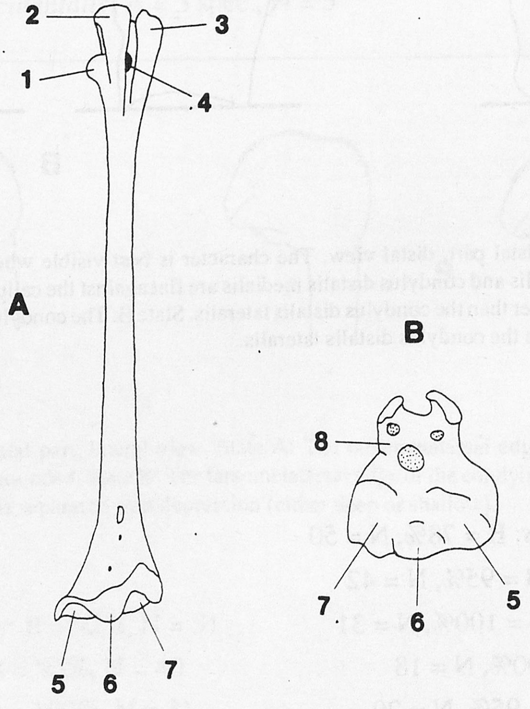

Fig. 70. Tarsometatarsus: nomenclature. A – dorsal view; B – proximal part, posterior view. 1 – Trochlea metatarsi II; 2 – Trochlea metatarsi III; 3 – Trochlea metatarsi IV; 4 – Foramen inferius; 5 – Facies articularis medialis; 6 – Condylus interarticularis; 7 – Facies articularis lateralis; 8 – Hypotarsus.

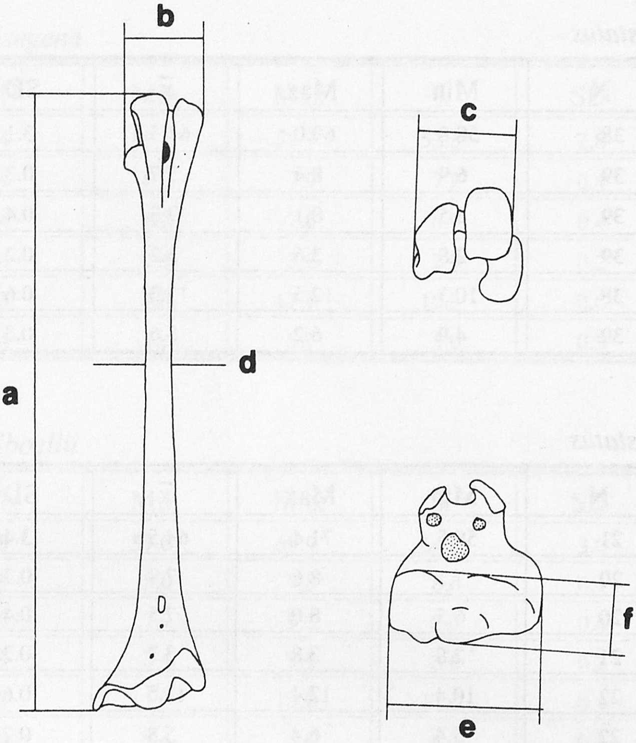

Fig. 71. Tarsometatarsus: measurements (ref. to Table XV). a – Total length: distance between the medial edge of the facies articularis medialis and the trochlea metatarsi III or IV (whichever is longer), measured with the shaft parallel to the axis of the calipers; b – Distal width: distance from the trochlea metatarsi II to the trochlea metatarsi IV, measured with the lateral side of the trochlea metatarsi IV flat against the calipers; c – Width of the two trochleas: distance from the trochlea metatarsi III to the trochlea metatarsi IV, measured with the lateral side of the trochlea metatarsi IV flat against the calipers and with the shaft perpendicular to the axis of the calipers; d – Minimum width of the shaft; e – Proximal width, measured with the articular surface parallel to the axis of the calipers; f – Height of the proximal articular part without the hypotarsus, measured with the plantar edges of the facies articularis medialis, facies articularis lateralis and with the dorsal side of the condylus interarticularis flat against the calipers.

Table XV

Tarsometatarsus (measured as in Fig. 71)

Podiceps cristatus

♂	N	Min	Max	$\bar{x}$	SD	CV
a **	35	61.4	70.3	66.1	2.5	3.8
b *	35	7.2	8.7	7.9	0.3	3.8
c **	35	6.9	8.1	7.5	0.3	4.0
d **	35	3.1	3.8	3.4	0.2	5.9
e **	35	10.5	12.5	11.7	0.5	4.3
f	35	4.9	6.4	5.7	0.3	5.3

Table XV cont.

Podiceps cristatus

♀	N	Min	Max	$\bar{x}$	SD	CV
a **	38	58.8	69.0	63.5	3.1	4.9
b *	39	6.9	8.4	7.7	0.3	3.9
c **	39	6.5	8.1	7.3	0.4	5.5
d **	39	2.8	3.6	3.2	0.2	6.2
e **	38	10.3	12.5	11.3	0.6	5.3
f	39	4.9	6.2	5.6	0.3	5.4

Podiceps cristatus

?	N	Min	Max	$\bar{x}$	SD	CV
a	21	58.5	71.4	64.5	3.4	5.3
b	20	7.1	8.6	7.9	0.3	3.8
c	20	6.5	8.0	7.5	0.4	5.3
d	21	2.8	3.8	3.3	0.3	9.1
e	22	10.4	12.4	11.5	0.6	5.2
f	22	5.4	6.4	5.8	0.2	3.4

Podiceps g. grisegena

♂	N	Min	Max	$\bar{x}$	SD	CV
a	15	52.6	60.2	56.8	2.4	4.2
b	15	7.0	8.2	7.7	0.4	5.2
c	15	6.6	7.9	7.3	0.4	5.5
d	15	2.7	3.5	3.1	0.2	6.5
e	15	10.0	12.1	11.0	0.6	5.5
f *	15	4.9	5.8	5.3	0.3	5.7

Podiceps g. grisegena

♀	N	Min	Max	$\bar{x}$	SD	CV
a	18	50.1	59.5	54.8	3.0	5.5
b	18	6.9	8.4	7.5	0.4	5.3
c	18	6.5	8.0	7.1	0.5	7.0
d	18	2.7	3.4	3.0	0.2	6.7
e	18	9.3	11.6	10.6	0.7	6.6
f *	18	4.5	5.8	5.1	0.3	5.9

Table XV cont.

Podiceps g. grisegena

?	N	Min	Max	$\overline{x}$	SD	CV
a	14	48.4	59.3	53.5	2.8	5.2
b	14	6.5	7.9	7.2	0.4	5.6
c	14	6.2	7.6	6.9	0.4	5.8
d	14	2.6	3.2	2.9	0.2	6.9
e	13	9.0	11.1	10.3	0.6	5.8
f	14	4.6	5.7	5.0	0.3	6.0

Podiceps g. holboellii

♂	N	Min	Max	$\overline{x}$	SD	CV
a	29	57.0	69.9	64.1	3.0	4.7
b **	29	8.0	9.5	8.8	0.4	4.5
c **	29	7.7	9.1	8.3	0.4	4.8
d	29	3.4	3.9	3.6	0.2	5.6
e **	29	11.7	13.2	12.4	0.4	3.2
f **	29	5.6	6.8	6.1	0.3	4.9

Podiceps g. holboellii

♀	N	Min	Max	$\overline{x}$	SD	CV
a	17	58.1	66.7	62.5	2.2	3.5
b **	17	7.5	9.1	8.4	0.4	4.8
c **	17	7.1	8.4	7.9	0.3	3.8
d	17	3.3	4.1	3.6	0.2	5.6
e **	17	10.9	12.8	11.9	0.6	5.0
f **	17	5.4	6.1	5.7	0.2	3.5

Podiceps g. holboellii

?	Measurements
a	60.5
b	8.9
c	8.2
d	3.4
e	11.5
f	5.4

Table XV cont.

Podiceps a. auritus (8 ?, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	9	40.6	47.1	43.8	2.4	5.5
b	9	5.0	5.8	5.5	0.3	5.5
c	9	4.9	5.7	5.3	0.2	3.8
d	9	1.9	2.6	2.2	0.2	9.1
e	9	7.7	8.5	8.0	0.3	3.8
f	9	3.6	4.3	3.9	0.2	5.1

Podiceps a. arcticus (4 ♂♂, 3 ♀♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	7	44.9	51.0	47.2	2.4	5.1
b	7	5.7	6.3	6.0	0.2	3.3
c	7	5.3	6.1	5.7	0.3	5.3
d	7	2.4	2.7	2.6	0.1	3.8
e	7	8.5	9.3	8.9	0.3	3.4
f	7	3.8	4.5	4.2	0.2	4.8

Podiceps auritus (*auritus* or *arcticus*; 1 ♀, 1 ?)

	Measurements	
a	42.2	42.7
b	5.4	5.6
c	5.3	5.6
d	2.1	2.2
e	8.1	8.2
f	4.0	4.1

Podiceps a. cornutus (1 ♂)

	Measurements
a	46.7
b	5.7
c	5.3
d	2.2
e	8.5
f	3.7

Podiceps n. nigricollis (13 ?, 2 ♂♂, 1 ♀)

	N	Min	Max	$\bar{x}$	SD	CV
a	16	40.4	45.2	43.1	1.5	3.5
b	16	5.3	6.0	5.6	0.2	3.6
c	16	5.0	5.7	5.3	0.2	3.8
d	16	1.8	2.6	2.2	0.2	9.1
e	16	7.3	8.4	7.7	0.3	3.9
f	16	3.4	4.0	3.7	0.2	5.4

Table XV cont.

Podiceps n. californicus (3 ♂♂, 1 ?)

	Measurements			
a	41.6	44.3	44.4	46.4
b	5.6	5.7	6.0	6.1
c	5.2	5.3	5.6	5.8
d	2.0	2.1	2.3	2.3
e	7.6	7.7	7.9	8.0
f	3.7	3.7	3.7	4.0

Tachybaptus r. ruficollis

♂	N	Min	Max	x̄	SD	CV
a	9	34.6	37.6	36.1	1.1	3.0
b *	9	5.1	5.5	5.3	0.1	1.9
c *	9	4.9	5.4	5.2	0.2	3.8
d	9	2.2	2.7	2.5	0.2	8.0
e	9	6.0	7.0	6.6	0.3	4.5
f	9	2.9	3.6	3.3	0.2	6.1

Tachybaptus r. ruficollis

♀	N	Min	Max	x̄	SD	CV
a	16	33.0	40.0	35.6	1.7	4.8
b *	16	4.8	5.4	5.1	0.2	3.9
c *	16	4.7	5.2	5.0	0.2	4.0
d	16	2.0	2.6	2.4	0.2	8.3
e	16	6.1	7.2	6.5	0.3	4.6
f	16	3.0	3.5	3.2	0.2	6.2

Tachybaptus r. ruficollis

?	N	Min	Max	x̄	SD	CV
a	23	32.5	37.3	35.2	1.2	3.4
b	23	4.8	5.5	5.1	0.2	3.9
c	23	4.8	5.4	5.0	0.2	4.0
d	23	2.0	2.6	2.3	0.2	8.7
e	23	6.0	7.0	6.5	0.2	3.1
f	23	2.8	3.5	3.2	0.1	3.1

Table XV cont.

Tachybaptus r. capensis (7 ?, 1 ♂)

	N	Min	Max	$\overline{x}$	SD	CV
a	8	31.7	36.5	34.7	1.5	4.3
b	8	4.6	5.5	5.1	0.3	5.9
c	8	4.6	5.2	5.0	0.2	4.0
d	8	2.2	2.6	2.3	0.2	8.7
e	8	6.1	6.8	6.5	0.2	3.1
f	8	2.9	3.4	3.2	0.2	6.2

Rollandia rolland (1 ♂, 1 ♀, 1 ?)

	Measurements		
a	34.1	36.7	38.2
b	5.3	5.6	5.6
c	5.1	5.5	5.6
d	2.3	2.4	2.5
e	7.0	7.1	7.2
f	3.2	3.4	3.5

Rollandia microptera (1 ♂)

	Measurements
a	53.0
b	7.9
c	7.6
d	3.4
e	10.7
f	5.1

Tachybaptus novaehollandiae (1 ♂, 1 ♀)

	Measurements	
a	34.1	36.1
b	5.3	5.4
c	5.1	5.2
d	2.3	2.7
e	6.3	6.4
f	3.3	3.5

Tachybaptus dominicus (2 ♂♂, 1 ♀, 1 ?)

	Measurements			
a	30.0	30.4	33.1	33.5
b	4.4	4.7	5.0	5.0
c	4.3	4.6	4.8	4.9
d	2.0	2.1	2.1	2.2
e	5.3	5.5	6.0	6.1
f	2.7	2.7	3.0	3.1

Podilymbus podiceps (2 ♀♀, 1 ♂, 2 ?)

	Measurements				
a	36.7	37.2	42.2	42.9	44.1
b	6.0	6.3	6.7	7.0	7.0
c	5.8	6.3	6.5	6.8	7.0
d	2.7	2.9	3.3	3.3	3.4
e	7.5	7.6	8.3	8.6	8.7
f	3.5	3.8	3.9	4.1	4.4

Poliocephalus poliocephalus (2 ?)

	Measurements	
a	39.5	39.7
b	5.2	5.3
c	4.9	5.1
d	2.1	2.2
e	6.8	7.3
f	3.3	3.4

Table XV cont.

"Podiceps" major (1 ♀, 1 ?)

	Measurements	
a	65.0	71.9
b	8.5	9.2
c	8.3	8.8
d	3.9	3.9
e	12.1	13.5
f	6.4	6.5

Podiceps occipitalis (2 ♂♂)

	Measurements	
a	41.5	43.7
b	6.1	6.7
c	5.5	6.3
d	2.3	2.4
e	7.9	8.4
f	3.7	4.1

Podiceps taczanowskii (1 ♀ imm.)

	Measurements
a	44.0
b	6.2
c	6.0
d	2.5
e	8.2
f	3.9

Podiceps gallardoi ? (1 ?)

	Measurements
a	47.7
b	6.8
c	6.2
d	2.7
e	9.0
f	4.4

Aechmophorus occidentalis (2 ♂♂, 2 ♀♀)

	Measurements			
a	74.2	76.6	77.8	79.8
b	8.6	8.9	9.2	9.9
c	8.2	8.7	9.0	9.1
d	3.0	3.6	3.7	3.7
e	12.5	13.5	13.6	14.1
f	6.0	6.4	6.5	6.9

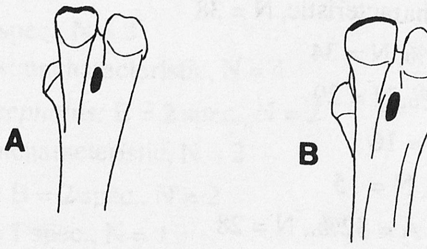

Fig. 72. Tarsometatarsus 1: distal part, dorsal view. State A: There is a slight depression in the articular surface of the trochlea metatarsi III. State B: There is no depression in the articular surface of the trochlea metatarsi III.

Podiceps cristatus: B = 97%, N = 39
P. g. grisegena: B = 100%, N = 35
P. g. holboellii: B = 97%, N = 29
P. auritus: B = 94%, N = 16
P. nigricollis: B = 100%, N = 15
Tachybaptus ruficollis: A = 96%, N = 28

Rollandia rolland: A = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

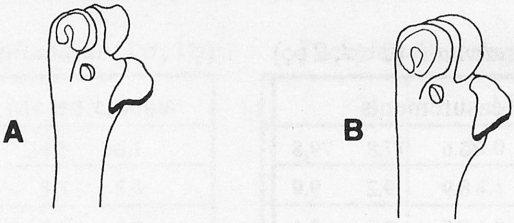

Fig. 73. Tarsometatarsus 2: distal part, lateroplantar view. State A: The plantaromedial edge of the trochlea metatarsi II is wavy, so that the end of the trochlea forms an elongated, narrow strip. State B: The plantaromedial edge of the trochlea metatarsi II is slanting, so that the end of the trochlea is wedge-shaped.

Podiceps cristatus: uncharacteristic, N = 38
P. g. grisegena: B = 94%, N = 34
P. g. holboellii: B = 76%, N = 29
P. auritus: B = 88%, N = 16
P. nigricollis: B = 87%, N = 15
Tachybaptus ruficollis: A = 82%., N = 28

Rollandia rolland: A = 3 spec., N = 3

R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

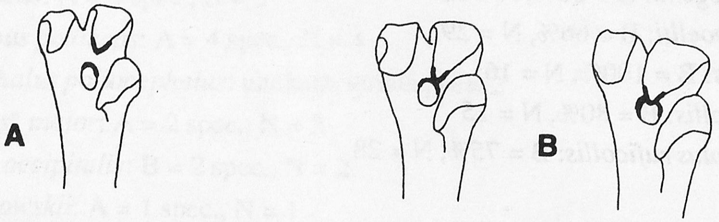

Fig. 74. Tarsometatarsus 3: distal part, plantar view. State A: The tip of the trochlea metatarsi III does not reach the rim of the foramen inferius. State B: The tip of the trochlea metatarsi III either reaches the rim of the foramen inferius or overlaps the foramen.

Podiceps cristatus: B = 94%, N = 51
P. g. grisegena: A = 79%, N = 43
P. g. holboellii: uncharacteristic, N = 29
P. auritus: uncharacteristic, N = 18
P. nigricollis: B = 71%, N = 21
Tachybaptus ruficollis: A = 100%, N = 31

Rollandia rolland: A = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: uncharacteristic, N = 4
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 2 spec., N = 3

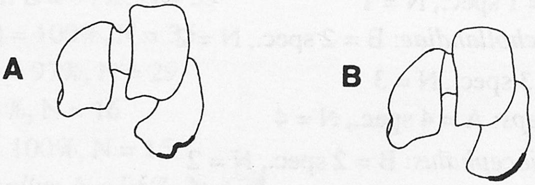

Fig. 75. Tarsometatarsus 4: distal part, distal view. State A: The plantaromedial edge of the trochlea metatarsi II is wavy. State B: The plantaromedial edge of the trochlea metatarsi II is rounded.

Podiceps cristatus: A = 68%, N = 38
P. g. grisegena: B = 66%, N = 35
P. g. holboellii: B = 66%, N = 29
P. auritus: B = 100%, N = 16
P. nigricollis: B = 80%, N = 15
Tachybaptus ruficollis: B = 75%, N = 28

Rollandia rolland: B = 2 spec., N = 3
*R. micropter*a: B = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 4 spec., N = 4
Poliocephalus poliocephalus: uncharacteristic, N 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

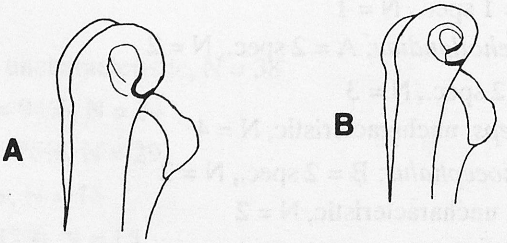

Fig. 76. Tarsometatarsus 5: distal part, lateral view. State A: The beginning of the rim (surrounding a circular depression on the lateral side of the trochlea metatarsi IV) is clearly distinguishable. State B: There is a gradual transition between the beginning and end of the rim surrounding a circular depression on the lateral side of the trochlea metatarsi IV.

Podiceps cristatus: A = 76%, N = 51
P. g. grisegena: uncharacteristic, N = 40
P. g. holboellii: uncharacteristic, N = 29
P. auritus: uncharacteristic, N = 17
P. nigricollis: B = 82%, N = 17
Tachybaptus ruficollis: A = 100%, N = 33

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: A = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: A = 2 spec., N = 3

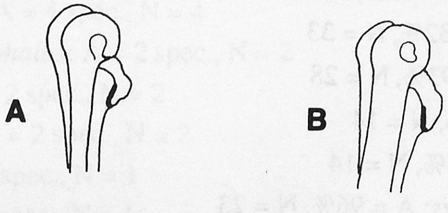

Fig. 77. Tarsometatarsus 6: distal part, lateral view. State A: The end of the lateral edge of the trochlea metatarsi II curves to the bone shaft. State B: The end of the lateral edge of the trochlea metatarsi II is approximately parallel to the bone shaft.

Podiceps cristatus: B = 97%, N = 39
P. g. grisegena: B = 77%, N = 35
P. g. holboellii: B = 86%, N = 29
P. auritus: B = 100%, N = 16
P. nigricollis: B = 93%, N = 15
Tachybaptus ruficollis: A = 93%, N = 28

Rollandia rolland: A = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1

Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: A = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

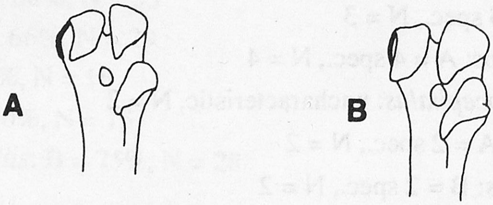

Fig. 78. Tarsometatarsus 7: distal part, plantar view. State A: There is a distinct bulge on the lateral side of the trochlea metatarsi IV. State B: There is no bulge on the lateral side of the trochlea metatarsi IV.

Podiceps cristatus: B = 73%, N = 37
P. g. grisegena: B = 82%, N = 33
P. g. holboellii: B = 93%, N = 28
P. auritus: B = 100%, N = 14
P. nigricollis: B = 93%, N = 14
Tachybaptus ruficollis: A = 96%, N = 23

Rollandia rolland: B = 2 spec., N = 3
*R. micropter*a: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

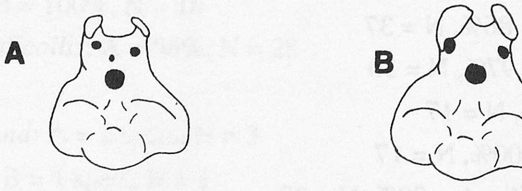

Fig. 79. Tarsometatarsus 8: proximal part, proximal view. The character was described by STORER (1963a). State A: There are four canals in the hypotarsus. State B: There are only three canals in the hypotarsus.

Podiceps cristatus: B = 100%, N = 41
P. g. grisegena: B = 100%, N = 35
P. g. holboellii: B = 100%, N = 29
P. auritus: B = 100%, N = 16
P. nigricollis: B = 100%, N = 16
Tachybaptus ruficollis: A = 100%, N = 27

Rollandia rolland: A = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: A = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczänowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

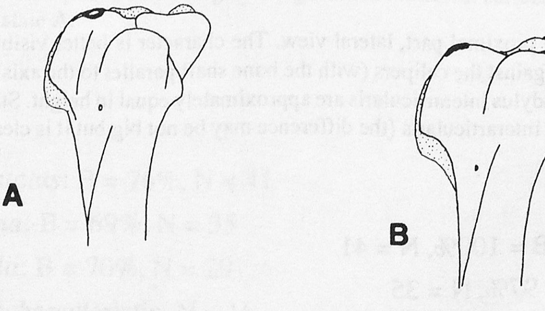

Fig. 80. Tarsometatarsus 9: proximal part, lateral view. State A: The opening of the lateralmost canal in the hypotarsus is visible. State B: The opening of the lateralmost canal in the hypotarsus is either invisible or scarcely visible.

Podiceps cristatus: B = 100%, N = 45
P. g. grisegena: B = 86%, N = 37
P. g. holboellii: B = 97%, N = 30
P. auritus: B = 94%, N = 17
P. nigricollis: B = 100%, N = 17
Tachybaptus ruficollis: A = 88%, N = 32

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

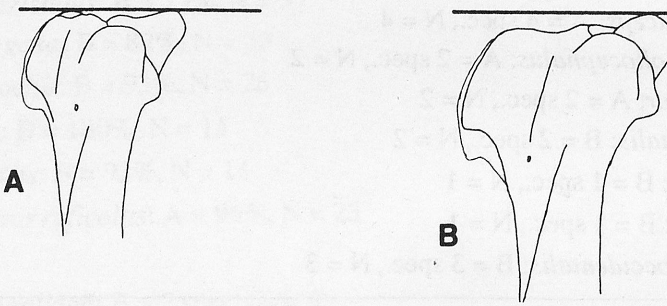

Fig. 81. Tarsometatarsus 10: proximal part, lateral view. The character is better visible when the condylus interarticularis is put flat against the calipers (with the bone shaft parallel to the axis of the calipers). State A: The hypotarsus and condylus interarticularis are approximately equal in height. State B: The hypotarsus is lower than the condylus interarticularis (the difference may be not big but it is clear).

Podiceps cristatus: B = 100%, N = 41
P. g. grisegena: B = 97%, N = 35
P. g. holboellii: B = 100%, N = 29
P. auritus: B = 100%, N = 16

P. nigricollis: B = 100%, N = 16
Tachybaptus ruficollis: A = 96%, N = 28

Rollandia rolland: A = 2 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2
T. dominicus: B = 2 spec., N = 3
Podilymbus podiceps: A = 3 spec., N = 4
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

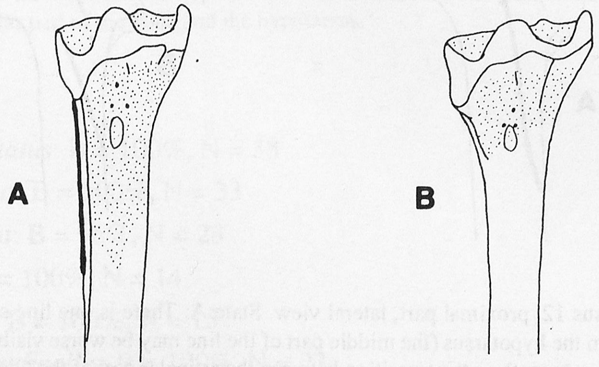

Fig. 82. Tarsometatarsus 11: proximal part, dorsal view. State A: The lateral edge of the shaft (up to the one-quarter of its length) is much higher than the dorsal surface of the shaft. State B: The lateral edge of the shaft (up to the one-quarter of its length) is higher than the dorsal surface of the shaft but the difference is smaller than in state A.

Podiceps cristatus: B = 76%, N = 41
P. g. grisegena: B = 69%, N = 35
P. g. holboellii: B = 70%, N = 29
P. auritus: uncharacteristic, N = 16
P. nigricollis: B = 94%, N = 16
Tachybaptus ruficollis: A = 82%, N = 28

Rollandia rolland: A = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: A = 2 spec., N = 2
T. dominicus: A = 3 spec., N = 3
Podilymbus podiceps: A = 4 spec., N = 4
Poliocephalus poliocephalus: B = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): uncharacteristic, N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

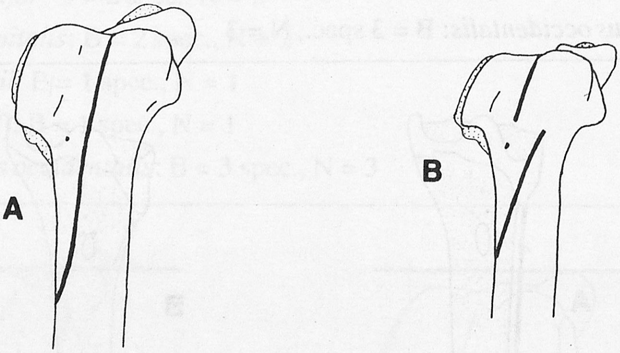

Fig. 83. Tarsometatarsus 12: proximal part, lateral view. State A: There is one line separating the articular part of the bone from the hypotarsus (the middle part of the line may be worse visible). State B: There are two lines (which do not meet) on the transition between the articular part of the bone and the hypotarsus.

Podiceps cristatus: A = 89%, N = 38
P. g. grisegena: B = 88%, N = 33
P. g. holboellii: B = 89%, N = 28
P. auritus: uncharacteristic, N = 13
P. nigricollis: B = 87%, N = 15
Tachybaptus ruficollis: B = 87%, N = 23

Rollandia rolland: B = 3 spec., N = 3
R. microptera: A = 1 spec., N = 1
Tachybaptus novaehollandiae: uncharacteristic, N = 2

T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 4 spec., N = 4
Poliocephalus poliocephalus: uncharacteristic, N = 2
"*Podiceps*" *major*: B = 2 spec., N = 2
Podiceps occipitalis: uncharacteristic, N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): A = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

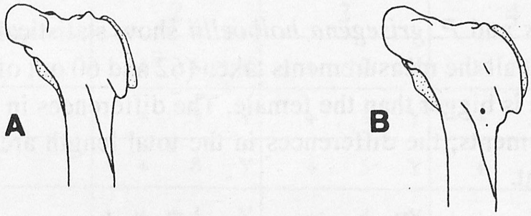

Fig. 84. Tarsometatarsus 13: proximal part, medial view. State A: There is no opening of any canal between the articular part of the bone and the hypotarsus. State B: There is one (sometimes two or more) opening between the articular part of the bone and the hypotarsus.

Podiceps cristatus: B = 100%, N = 38
P. g. grisegena: B = 100%, N = 33
P. g. holboellii: B = 96%, N = 28
P. auritus: B = 100%, N = 14
P. nigricollis: B = 100%, N = 15
Tachybaptus ruficollis: B = 100%, N = 23

Rollandia rolland: B = 3 spec., N = 3
R. microptera: B = 1 spec., N = 1
Tachybaptus novaehollandiae: B = 2 spec., N = 2
T. dominicus: B = 3 spec., N = 3
Podilymbus podiceps: B = 4 spec., N = 4
Poliocephalus poliocephalus: A = 2 spec., N = 2
"*Podiceps*" *major*: uncharacteristic, N = 2
Podiceps occipitalis: B = 2 spec., N = 2
P. taczanowskii: B = 1 spec., N = 1
P. gallardoi (?): B = 1 spec., N = 1
Aechmophorus occidentalis: B = 3 spec., N = 3

V. SEXUAL DIMORPHISM

1. RESULTS

Table XVI summarizes the data on sexual dimorphism in size in four taxa of grebes. The data on *P. nigricollis* are not included in this comparison since they are incomplete. The remaining taxa (species and subspecies) were not examined in this respect because the specimens were either too scanty or unsexed. In all the cases in which sexual dimorphism in size is significant, the male is larger than the female, but all the dimensions show a considerable overlap between the sexes.

Podiceps cristatus and *P. grisegena holboellii* show statistically significant sexual dimorphism in almost all the measurements taken (62 and 60 out of 73, respectively). In all the cases the male is bigger than the female. The differences in size are very distinct in all the skeletal elements; the differences in the total length are in all but one cases statistically significant.

Unlike the previous species, *P. g. grisegena* and *Tachybaptus r. ruficollis* show sexual dimorphism only in 19 and 14 measurements, respectively, males being bigger than females. In both cases sexual dimorphism in size is present in the skull (cranium and mandible). As regards the wing and leg bones it is found only in a few measurements, and even then it usually does not include the total length.

The differences in sexual dimorphism between the two subspecies of *P. grisegena* (*P. g. grisegena* and *P. g. holboellii*) are very distinct; the former subspecies has relatively few size differences between the sexes, while the sexes of the latter subspecies differ considerably in size in most of the skeletal measurements.

2. DISCUSSION AND COMMENTS

Surprisingly few data on sexual dimorphism in size of the four taxa of grebes examined in this paper, can be found in the literature. Even the papers which deal with dimorphism, usually give only standard external measurements. Thus, it seems that this paper is probably the first to provide the data on sexual dimorphism in skeletal elements in the four species of grebes; anyway it certainly provides the most exact data. CRAMP (1977) reported statistically significant sexual dimorphism in *P. cristatus*, *P. g. grisegena* and *T. r. ruficollis*. The differences included the lengths of the wing, bill, tarsus and (with the exception of *T. ruficollis*) middle toe. His data do not entirely agree with those reported by PIERSMA (1988a), who failed to find statistically significant differences in size between the male and female of *P. g. grisegena*. BANDORF (1970), DEMENTIEV et al. (1951) and KUROTCHKIN (1985) gave measurements (ranges and means) for *T. r. ruficollis* but they did not inform whether the differences between the sexes were statistically significant. Judging from the ranges and arithmetic means, one can only speculate that the male does not differ very much from the female. As regards *P. cristatus*, PIERSMA (1988b) have

Table XVI

Sexual dimorphism in four taxa of grebes investigated. Column 1: figures in brackets indicate total number of measurements; Columns 2–5: + & – indicate presence or absence of sexual dimorphism; figures indicate number of measurements showing statistically significant sexual dimorphism; Y & N indicate whether significant sexual dimorphism in total length was (Y) or was not (N) observed.

Skeletal elements	*P. cristatus*	*P. g. holboellii*	*P. g. grisegena*	*T. r. ruficollis*
1	2	3	4	5
Cranium (10)	+ 8 Y	+ 10 Y	+ 7 Y	+ 4 N
Mandibula (3)	+ 3 Y	+ 3 Y	+ 3 Y	+ 2 Y
Sternum (8)	+ 8 Y	+ 5 Y	+ 1 N	+ 1 N
Coracoideum (4)	+ 4 Y	+ 4 Y	+ 2 Y	+ 1 Y
Scapula (2)	+ 1 –	+ 1 –	–	–
Humerus (6)	+ 4 Y	+ 6 Y	–	+ 1 N
Radius (3)	+ 2 Y	+ 3 Y	–	–
Ulna (5)	+ 4 Y	+ 4 Y	–	–
Carpometacarpus (7)	+ 6 Y	+ 5 Y	+ 1 N	–
Phalanx Dig. Maj. I (1)	+ 1 Y	+ 1 Y	–	–
Pelvis (5)	+ 3 Y	+ 2 Y	+ 1 N	+ 1 Y
Femur (6)	+ 6 Y	+ 6 Y	+ 1 N	+ 2 Y
Tibiotarsus (7)	+ 7 Y	+ 6 Y	+ 2 Y	–
Tarsometatarsus (6)	+ 5 Y	+ 4 N	+ 1 N	+ 2 N
TOTAL (73)	62	60	19	14

found significant sexual differences in the lengths of body, wing, bill, tarsus and keel (i. e. in all dimensions analysed). Although none of the authors (DEMENTIEV et al. 1951; KUROTCHKIN 1985; PALMER 1962) says anything about statistically significant differences between the sexes of *P. g. holboellii*, having compared the ranges and arithmetic means, one can see that the sexes of this subspecies differ considerably in size. Many authors published the standard external measurements separately for males and females of various grebe species, and, although in almost all cases the males were larger than the females, the authors did not mention whether the differences were statistically significant

(e. g. AHLÉN 1961; BAUER and GLUTZ VON BLOTZHEIM 1966; HOFER 1969; PALMER 1962).

Owing to various methods of taking measurements, it is difficult to compare directly the external lengths of the bill and tarsus with the lengths of the corresponding bones; other external measurements are even more problematic. However, sexual dimorphism in the size of *P. cristatus* and *P. g. holboellii* may be taken for granted both as regards the external and the skeletal measurements. The situation is not so clear in *P. g. grisegena* and *T. r. ruficollis*. Here, the differences between the male and female in the length of the tarsus were reported to be significant (CRAMP 1977) but the total lengths of the tarsometatarsi in the two sexes of these species do not differ significantly in the light of the present data (Table XVI). Moreover, according to CRAMP (1977), the males and females of these two species differed significantly in respect of wing length. The present results do not confirm it, since out of all the total lengths of the wing elements in *P. g. grisegena*, only the length of the phalanx dig. majoris I showed sexual dimorphism, and in *T. r. ruficollis* – only the humerus (Table XVI). Such inconsistency may result from two things: (1) the small differences in the lengths of the skeletal elements of the wing cumulate and the total length of the wing differs significantly between the sexes, and/or (2) the lengths of the primaries of the male differ from those of the female. In the latter case the results of a direct comparison of the skeletal measurements and the length of the wing would be at least questionable. Moreover, according to BOCHEŃSKI & BOCHEŃSKI Jr. (1992), the length of the wing is correlated rather with the width of the bone end (proximal and/or distal part) than with the bone length.

Although, according to SELANDER (1966), there is variation in the degree of sexual dimorphism in size within species even at population level, the differences between the two subspecies of *P. grisegena* are so big that they most probably go beyond the range of variation of one species.

One of the possible explanations of the size differentiation between *P. g. holboellii* and *P. g. grisegena* is character displacement (FJELDSÅ 1982a, 1983a). According to this theory, *P. grisegena* managed to invade the range of *P. cristatus* by evolving a smaller size and a smaller bill suited for taking invertebrate prey. The present results suggest that besides becoming smaller, either *P. g. grisegena* lost much of its sexual dimorphism or *P. g. holboellii* developed sexual dimorphism, "taking advantage" of the absence of *P. cristatus* within its range.

VI. OSTEOLOGICAL EVIDENCE

1. RESULTS

Table XVII gives the total number of characters whose states were identical in each pair of species.

Table XVII

Numbers of characters shared by each pair of species (calculated from all 55 characters described)

Species	R. rolland	R. microptera	T. novaeholl	T. ruficollis	T. dominicus	Pod. podiceps	Pol. polioceph.	"P." major	P. auritus	P.g. grisegena	P.g. holboellii	P. cristatus	P. nigricollis	P. occipitalis	P. taczanowski	P. gallardoi	A. occidentalis
Rollandia rolland	×	39	30	35	34	24	19	15	24	28	23	21	23	23	27	25	19
Rollandia microptera		×	23	27	33	22	25	16	30	33	28	28	32	30	33	30	24
Tachybaptus novaehollandiae			×	37	31	24	18	12	19	21	18	16	16	16	20	20	12
Tachybaptus ruficollis				×	34	31	20	12	18	20	17	15	15	14	19	20	12
Tachybaptus dominicus					×	25	17	17	28	30	27	27	24	25	28	28	24
Podilymbus podiceps						×	12	13	14	15	17	14	12	10	15	17	13
Poliocephalus poliocephalus							×	15	23	23	20	21	20	20	19	21	16
"Podiceps" major								×	20	21	22	23	21	21	16	20	25
Podiceps auritus									×	33	32	34	33	32	28	34	26
Podiceps g. grisegena										×	40	33	35	33	34	32	29
Podiceps g. holboellii											×	31	29	28	28	31	29
Podiceps cristatus												×	30	32	28	32	28
Podiceps nigricollis													×	42	36	34	31
Podiceps occipitalis														×	34	34	30
Podiceps taczanowskii															×	30	26
Podiceps gallardoi																×	26
Aechmophorus occidentalis																	×

2. COMPARISONS AND COMMENTS

It would certainly have been possible to describe more osteological characters distinguishing extra-European species. This was, however, given up, since the small number of specimens examined might cause many mistakes. For the same reason, some of the character states of the extra-European species may appear wrong. One character (the relative height of the crista sterni) was not included in the paper because it was described in detail by LIVEZEY (1989).

The results concerning the species *P. gallardoi* should be treated with caution since (according to the label of the specimen) it is absolutely not certain whether the postcranial elements of the skeleton belong to that species. In spite of that the results are presented here because the bones do not match any other species and the skeletal specimens of *P. gallardoi* are extremely rare (WOOD & SCHNELL 1986).

Out of 55 characters described, 22 are typical of one species only. Seventeen of them were found on the head (skull and mandible) and five on the postcranial elements. *A. occidentalis* shows seven such characters (skull: 4, 5, 7, 8, Figs. 6–7, 9–10; mandibula: 2, 3, 4, Figs. 14–16), *P. podiceps* five (skull: 3, 4, Figs. 5–6; mandibula: 4, 7, Figs. 16, 19; pelvis: 1, Fig. 57), *T. ruficollis* two (radius: 1, Fig. 40; scapula: 2, Fig. 32) and *P. gallardoi* two (skull: 5, Fig. 7; mandibula: 2, Fig. 14). Each of the remaining six species shows one character which is typical exclusively of it: *T. dominicus* (skull:4, Fig. 6), *P. poliocephalus* (tarsometatarsus: 13, Fig. 84), "*P.*" *major* (skull: 4, Fig. 6), *P. g. grisegena* (ulna: 1, Fig. 43), *P. nigricollis* (skull: 5, Fig. 7) and *P. occipitalis* (mandibula: 2, Fig. 14).

Three characters are typical of one genus exclusively. Two of them refer to *Rollandia* (skull: 6, Fig. 8; clavicula: 1, Fig. 28) and one to *Tachybaptus* (carpometacarpus: 3, Fig. 48).

Four characters divide all the genera of *Podicipedidae* into two groups consisting of two or more genera. Each division is different from the remaining ones.

1). Mandibula 5 (Fig. 17): *Poliocephalus* + "*P.*" *major* + *Aechmophorus* versus *Rollandia* + *Tachybaptus* + *Podilymbus* + *Podiceps*.

2). Mandibula 6 (Fig. 18): *Podilymbus* + "*P.*" *major* versus *Rollandia* + *Tachybaptus* + *Poliocephalus* + *Podiceps* + *Aechmophorus*.

3). Tibiotarsus 2 (Fig. 68): *Podiceps* + *Aechmophorus* versus *Rollandia* + *Tachybaptus* + *Podilymbus* + "*P.*" *major*. (*Poliocephalus* – "uncharacteristic").

4). Tarsometatarsus 7 (Fig. 78): *Tachybaptus* + *Podilymbus* versus *Rollandia* + *Poliocephalus* + *Podiceps* + *Aechmophorus*. (No data on "*P.*" *major*).

The character, described as pelvis 1 (Fig. 57), divides all the genera of *Podicipedidae* into three groups: *Rollandia* + *Tachybaptus* versus *Podilymbus* versus *Poliocephalus* + "*P.*" *major* + *Podiceps* + *Aechmophorus*.

Although the character tarsometatarsus 8 (Fig. 79) was described by STORER (1963a), it must be presented here as well. Together with some anatomical and behavioural evidence, it divides *Podicipedidae* into two groups (*Podilymbini* and *Podicipedini*) but *T. dominicus* shows a state which is characteristic of the genus *Podiceps*. In spite of this inconsistency, this is the only character in this study which correctly classifies 100 % of the specimens from each species. The division is as follows: *Rollandia* + *Tachybaptus* (excluding *T. dominicus*) + *Podilymbus* + *Poliocephalus* + "*P.*" *major* versus *T. dominicus* + *Podiceps* + *Aechmophorus*.

The most differentiated characters (i. e. showing many various states) are: skull 4 (Fig. 6) – 7 states, and mandibula 2 (Fig. 14) – 6 states. Most of the other characters (46 out of 55) show only two states. It is probably connected with the fact that the head often shows more species-specific adaptations than other parts of the body do.

The species in each of the three genera: *Rollandia*, *Tachybaptus* and *Podiceps* (excluding "*P.*" *major*) share more characters between them than with any other taxa. The two species of the genus *Rollandia* (*rolland* and *microptera*) share the same states of 39 characters, which is, in fact, one of the highest scores. Three species of the genus *Tachybaptus* (*ruficollis*, *novaehollandiae* and *dominicus*) have 31–37 characters in common. Somewhat wider range of the number of common characters is found in the species of *Podiceps* (28–42). (Because of its morphological differences "*P.*" *major* is not included here. Instead, it is treated separately). The genus *Podiceps* may be divided into two groups, in which the species show even higher numbers of common characters: 1) *P. auritus*, *P. g. grisegena*, *P. g. holboellii*, *P. cristatus* (31–40), and 2) *P. nigricollis*, *P. taczanowskii*, *P. gallardoi* (30–42). The number of characters shared by the members of these two groups is slightly lower (28–35). Thus, it seems that the lower limit of approximately 30 common characters is typical of generic level. Two species of the genus *Podiceps* (*P. nigricollis* and *P. occipitalis*) have more common characters (42) than any other pair of species. This indicates their great similarity or even relationship, which agrees with FJELDSÅ's (1982b) results.

Since the remaining genera are represented in this paper by single species only, it seemed advisable to present graphically their morphological affinities with the other taxa. The data listed below are based on Table XVII and they summarize the number of characters shared by a given species with the remaining taxa. The numbers give a rough idea of the extent to which the taxa are related to each other.

Podilymbus podiceps

Rollandia 22–24
Tachybaptus 24–31
Poliocephalus 12
"*P.*" *major* 13
Podiceps 10–17
Aechmophorus 13

As shown above, *P. podiceps* is much closer to *Tachybaptus* and *Rollandia* than to any other taxa.

Poliocephalus poliocephalus

Rollandia 19–25
Tachybaptus 17–20
Podilymbus 12
"*P.*" *major* 15
Podiceps 19–23
Aechmophorus 16

P. poliocephalus seems to be more similar to *Rollandia* and *Podiceps* than to the remaining taxa.

"Podiceps" major	*Rollandia* 15–16
	Tachybaptus 12–17
	Podilymbus 13
	Poliocephalus 15
	Podiceps 16–23
	Aechmophorus 25

Judging from the number of common characters, "*P*." *major* resembles *Aechmophorus* in the first place and, to a lesser degree, *Podiceps*. It shares much fewer characters with the other taxa. However, 25 common characters with *Aechmophorus* and up to 23 with Podiceps is well below the number typical of generic level (i. e. 30 or more). This suggests that "*P*." *major* could be placed in a separate, one-species genus.

Aechmophorus occidentalis	*Rollandia* 19–24
	Tachybaptus 12–24
	Podilymbus 13
	Poliocephalus 16
	"*P*." *major* 25
	Podiceps 26–31

Aechmophorus occidentalis is most similar to the genus *Podiceps* but (as shown below) it differs from it as well as from the other taxa in so many characters that it may be considered a distinctive genus.

It is worth noticing that (with two exceptions) the numbers of common characters in the four groups listed above generally do not reach the level which was observed in *Rollandia*, *Tachybaptus* or *Podiceps* (i. e. thirty and more common characters).

Table XVII shows also that the species of *Rollandia* and *Tachybaptus* have 23–35 characters in common. The corresponding figures for *Rollandia* and *Podiceps* are 21–33 and for *Tachybaptus* and *Podiceps* (excluding "*P*." *major*) – 14–30, depending on the pairs of species.

A comparison of the position of *T. dominicus* with that of the remaining genera presents itself as follows:

Tachybaptus dominicus	*Rollandia* 33–34
	Tachybaptus 31–34
	Podilymbus 25
	Poliocephalus 17
	"*P*." *major* 17
	Podiceps 24–30
	Aechmophorus 24

It indicates that *T. dominicus* is equally similar to the genera *Tachybaptus* and *Rollandia*, having fewer characters in common with the remaining taxa.

A similar comparison of the position of *P. g. holboellii* with that of *P. g. grisegena* and *P. cristatus* (which is the second closest species in size to *P. g. holboellii*) is as follows:

P. g. grisegena 40

P. g. holboellii

P. cristatus 31

It indicates that *P. g. holboellii* is much more similar to *P. g. grisegena* than to *P. cristatus*. However, 40 common characters out of 55 form 73 % only, which is a rather poor result for specimens representing the same species. This suggests that *P. g. holboellii* may deserve a species status. Of all the characters differentiating the two subspecies, only one (ulna: 1, Fig. 43) is univocal (*P. g. grisegena* shows the "A" state, and *P. g. holboellii* the "B" state). The remaining differences are limited to one of the subspecies which shows a certain state, while the second subspecies is "uncharacteristic".

VII. CLUSTER ANALYSIS

1. RESULTS

The squared Mahalanobis distances between the taxa are listed in Table XVIII . The phenogram from this matrix (Fig. 85) indicates four to five distinct clusters. The first cluster comprises four species of two genera: *R. rolland*, *T. r. ruficollis*, *T. novaehollandiae* and *T. dominicus*. *Poliocephalus poliocephalus* is intermediate between *T. dominicus* and *Podilymbus podiceps* but it seems that it may be treated as a distinct one-species group. Another one-species group is that of *P. podiceps*. "*P.*" *major* and *A. occidentalis* stand relatively close to each other; they are separated from the other clusters of the family. The species of the genus *Podices* (excluding "*P.*" *major*) form a very distinct cluster, divided into two small sub-groups: *P. a. auritus*, *P. a. arcticus*, *P. n nigricollis*, *P. n. californicus* and *P. g. grisegena*, *P. g. holboellii*, *P. cristatus*.

2. COMMENTS

The results of the cluster analysis indicate that *R. rolland* is so close to the genus *Tachybaptus* that it might be included in it. However, the analysis was based on too few specimens from *Rollandia* and *Tachybaptus* to allow us to risk such a conclusion. Moreover, the remaining species of *Rollandia* should also be examined. The distinctness of *P. podiceps* from the other taxa is clear; *P. poliocephalus* is somewhat less distinct but it does not fit into any other genus either. "*P.*" *major* is definitely separated from its

Table XVIII

Squared Mahalanobis distances between 15 taxa of grebes

Taxa (No of specimens)	*Rollandia rolland*	*Tachybaptus novaehollandiae*	*Tachybaptus r. ruficollis*	*Tachybaptus dominicus*	*Podilymbus podiceps*	*Poliocephalus poliocephalus*	"*Podiceps*" *major*	*Podiceps a. auritus*	*Podiceps a. arcticus*	*Podiceps g. grisegena*	*Podiceps g. holboellii*	*Podiceps cristatus*	*Podiceps n. nigricollis*	*Podiceps n. californicus*	*Aechmophorus occidentalis*
R. rolland (3)	×														
T. novaehollandiae (2)	131.12	×													
T. r. ruficollis (32)	82.23	129.58	×												
T. dominicus (2)	169.90	150.39	182.24	×											
P. podiceps (2)	273.56	251.52	366.36	375.08	×										
P. poliocephalus (2)	219.56	155.46	174.44	257.25	432.52	×									
"*P.*" *major* (2)	1062.20	876.82	1126.85	1076.62	1127.31	852.54	×								
P. a. auritus (5)	597.83	424.02	539.62	682.78	772.64	232.75	575.20	×							
P. a. arcticus (3)	553.59	387.53	496.36	630.03	699.63	217.58	569.68	36.83	×						
P. g. grisegena (28)	638.80	419.38	653.20	665.34	692.88	336.47	330.75	114.18	103.15	×					
P. g. holboellii (45)	765.47	524.53	775.29	780.47	796.53	440.31	262.57	169.08	166.59	27.06	×				
P. cristatus (61)	868.68	614.10	905.72	870.53	856.24	505.96	218.74	247.31	237.81	68.34	57.65	×			
P. n. nigricollis (4)	505.49	338.35	501.47	569.25	690.00	208.19	551.85	105.07	97.00	122.21	185.09	231.06	×		
P. n. californicus (3)	548.22	395.51	521.73	617.32	779.96	242.51	420.82	103.54	103.21	103.00	123.11	205.36	42.79	×	
A. occidentalis (2)	1455.14	1238.43	1495.26	1393.50	1446.80	1190.24	188.14	833.65	854.63	563.85	472.37	421.81	804.76	663.28	×

congeners; together with *A. occidentalis* they are far from the other taxa. The remaining taxa of *Podiceps* are very similar to one another, as the linkage distances within their cluster are relatively small. The cluster of the *Podiceps* species consists of four species, three of them are represented by two subspecies each. In all the cases both subspecies are closer to each other than to any other taxa, which may confirm their taxonomic position.

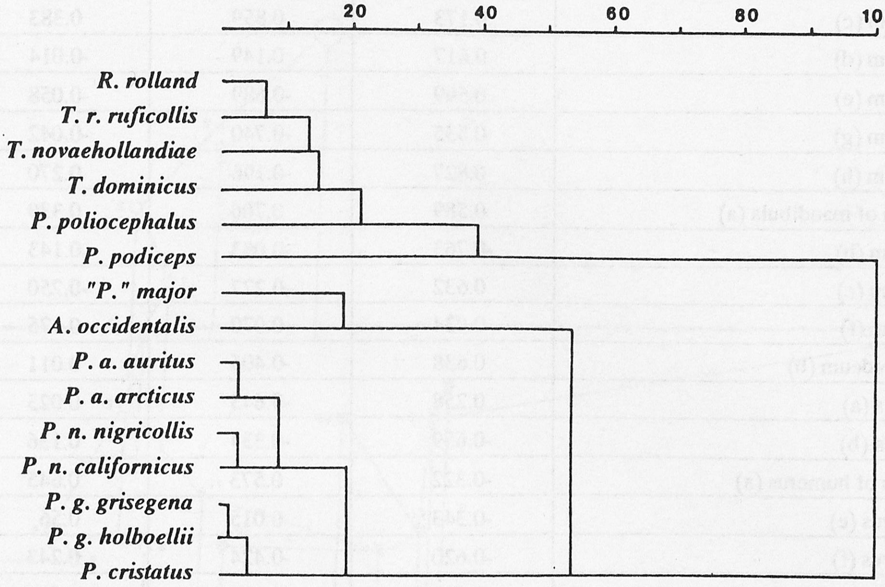

Fig. 85. Phenogram based on the matrix of Squared Mahalanobis distances. The horizontal axis represents the percentage of the range from the maximum to the minimum distance in the data.

VIII. PRINCIPAL COMPONENT ANALYSIS

1. RESULTS

The results of the principal component analysis (PCA) are given in Table XIX and Fig 86 . Component I divides the taxa into six (seven) groups, which can be seen in the diagram (Fig. 86): 1) members of the genus *Podiceps* (excluding "*P.*" *major*); 2) four taxa of *Tachybaptus* and *R. rolland*; 3) *R. microptera*; 4) *A. occidentalis*; 5) "*P.*" *major*; and possibly 6) *P. podiceps* and *P. poliocephalus*. Component II separates *A. occidentalis*, "*P.*" *major* and one part of *Podiceps* from the other part of *Podiceps*, *Tachybaptus*, *Rollandia*, *Poliocephalus* and *Podilymbus*. Component III contrasts the species within *Podiceps* and *Tachybaptus*.

Table XIX

Character loadings and percent variance for the first three principal components from principal component analysis. Letters in brackets refer to appropriate measurements

Characters	I	II	III
Length of cranium (a)	0.700	0.546	0.357
Cranium (b)	0.411	0.792	0.352
Cranium (c)	0.173	0.859	0.383
Cranium (d)	0.617	0.149	-0.014
Cranium (e)	0.599	-0.689	-0.058
Cranium (g)	0.535	-0.740	-0.042
Cranium (h)	0.827	-0.196	0.270
Length of mandibula (a)	0.589	0.706	0.339
Sternum (b)	-0.763	-0.083	0.143
Sternum (c)	0.632	-0.277	-0.250
Sternum (f)	-0.934	-0.070	0.175
Coracoideum (b)	0.638	-0.405	0.011
Scapula (a)	0.258	-0.643	0.025
Scapula (b)	-0.659	-0.334	0.136
Length of humerus (a)	-0.322	0.573	0.645
Humerus (e)	-0.343	0.015	0.56
Humerus (f)	-0.620	-0.424	0.243
Length of ulna (a)	-0.718	-0.016	0.597
Ulna (c)	-0.442	-0.442	0.121
Ulna (d)	-0.274	-0.559	0.199
Ulna (e)	-0.026	-0.566	0.552
Length of carpometacarpus (a)	-0.670	-0.145	0.529
Carpometacarpus (c)	0.237	-0.727	0.388
Carpometacarpus (d)	0.058	-0.577	0.550
Pelvis (d)	0.634	0.619	0.007
Length of femur (a)	0.703	-0.622	0.012
Femur (b)	0.951	-0.161	0.019
Femur (d)	0.833	0.265	0.042
Length of tibiotarsus (a)	0.865	0.322	0.100
Tibiotarsus (f)	0.868	-0.272	0.188
Tibiotarsus (g)	0.895	0.000	0.153
Length of tarsometatarsus (a)	0.784	0.071	0.196
Tarsometatarsus (c)	0.727	-0.508	0.194
Tarsometatarsus (d)	0.740	-0.300	0.158
Tarsometatarsus (e)	0.888	-0.012	0.177
Percent variance	41.94	21.83	9.03

Of the 35 characters (Table XIX), 15 have high loadings (absolute value 0.7) on component I (12 positive and 3 negative). Ten of them refer to the bones of the leg, two to the skull and three to other skeletal elements. Five characters load heavily on component II (2 positive and 3 negative). Four of them refer to the head (skull with mandible) and one to the carpometacarpus. Two characters (length of humerus and length of ulna) load relatively heavily (absolute value 0.6) on component III.

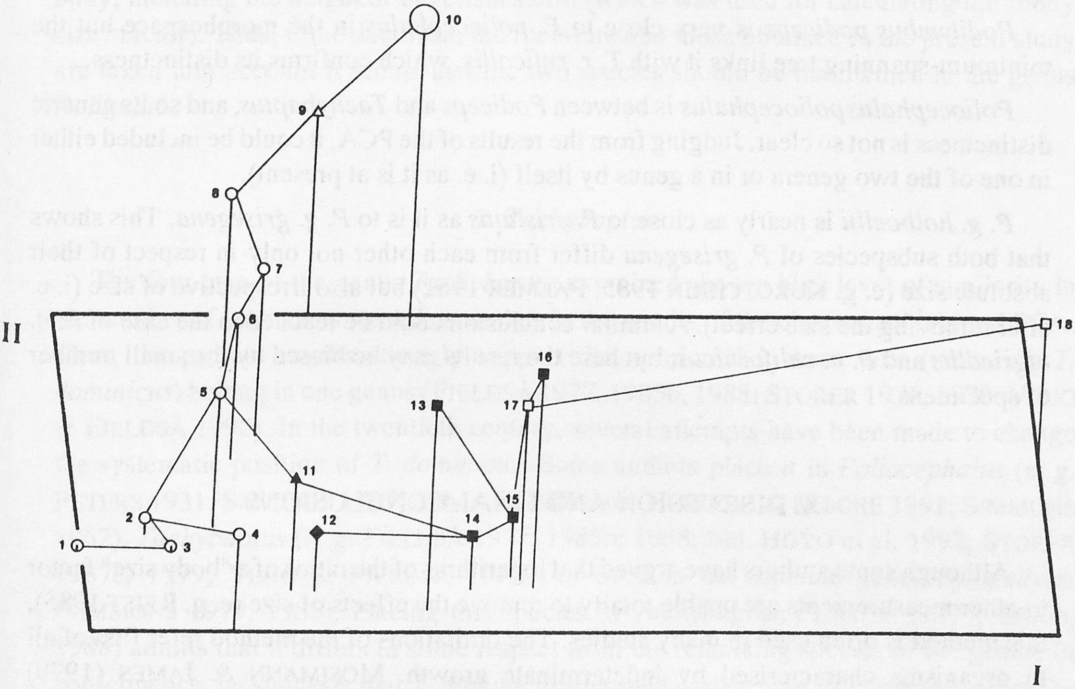

Fig. 86. Projection of 18 taxa of grebes onto first three principal components from transformed data matrix. Component III indicated by height. The minimum-spanning tree is superimposed on the plot. Small open circles mark the genus *Podiceps*; big open circle – "*P.*" *major*; open triangle – *Aechmophorus*; filled triangle – *Poliocephalus*; filled diamond – *Podilymbus*; filled squares – *Tachybaptus*; open squares – *Rollandia*. Species are: 1 – *P. n. nigricollis*; 2 – *P. a. arcticus*; 3 – *P. a. auritus*; 4 – *P. occipitalis*; 5 – *P. n. californicus*; 6 – *P. g. grisegena*; 7 – *P. g. holboellii*; 8 – *P. cristatus*; 9 – *A. occidentalis*; 10 – "*P.*" *major*, 11 – *P. poliocephalus*; 12 – *P. podiceps*; 13 – *T. novaehollandiae*; 14 – *T. r. ruficollis*; 15 – *T. r. capensis*; 16 – *T. dominicus*; 17 – *R. rolland*; 18 – *R. microptera*.

2. COMMENTS

The *Podiceps* group (excluding "*P.*" *major*) is somewhat elongated and it can be divided into two sub-groups: *P. occipitalis*, *P. a. auritus*, *P. a. arcticus*, and *P. n. nigricollis* versus *P. n. californicus*, *P. g. grisegena*, *P. g. holboellii* and *P. cristatus*. The minimum-spanning tree superimposed on the three-dimensional diagram (Fig. 86) confirms the unity of the genus since all members of the group are connected with each other without the connected group including a nonmember of the genus.

"*Podiceps*" *major* is separated from its "congeners" by *A. occidentalis*, which is clearly visible in the results of the PCA, and the minimum-spanning tree. It indicates that this species does not fit into the genus *Podiceps*.

Rollandia rolland is more similar to the genus *Tachybaptus* than to *R. microptera* (the latter species being completely different from all other taxa). This is most probably due to the fact that *R. microptera* is the only flightless species under analysis. The minimum-spanning tree links the two species of *Rollandia*, which indicates their similarity.

Podilymbus podiceps is very close to *P. poliocephalus* in the morphospace but the minimum-spanning tree links it with *T. r. ruficollis*, which confirms its distinctness.

Poliocephalus poliocephalus is between *Podiceps* and *Tachybaptus*, and so its generic distinctness is not so clear. Judging from the results of the PCA, it could be included either in one of the two genera or in a genus by itself (i. e. as it is at present).

P. g. holboellii is nearly as close to *P. cristatus* as it is to *P. g. grisegena*. This shows that both subspecies of *P. grisegena* differ from each other not only in respect of their absolute size (e. g. KUROTCHKIN 1985; PALMER 1962) but also irrespective of size (i. e. after removing the size effect). A similar conclusion could be reached in the case of *P. n. nigricollis* and *P. n. californicus*, but here the results may be biased by the small number of specimens.

IX. DISCUSSION AND FINAL CONCLUSIONS

Although some authors have argued that logarithms of the ratios of a "body size" factor to other measurements are unable totally to remove the effects of size (e. g. REIST 1985), this method is often used in many studies. The limitations of the method refer first of all to organisms characterised by indeterminate growth. MOSIMANN & JAMES (1979) indicated that, in many cases, logarithms of ratios were capable of producing size-free shape variates, if the data originated from organisms of determinate growth. Thus, it seems that even if the method is not perfect, it may be used in studies of bird systematics.

The results for the species represented by one to several specimens should be treated only as approximations; they provide valuable information on the general affinities of the species but some details may differ from those described in this paper.

1. *Rollandia*

The present results, regarding the affinities between the species of *Rollandia*, do not entirely agree with the data from the literature. There is no doubt that the two species (*R. rolland* and *R. microptera*) belong to one genus (FJELDSÅ 1977, 1985a, 1985b, 1988; SANDERS 1967; STORER 1963a, 1967a, 1967b, 1979), which was well-documented by their behaviour, patterns of the downy young, hypotarsal character and some other anatomical evidences. The number of osteological characters shared by the two species fully confirms their close relationship. On the other hand, the results of the cluster and principal component analyses suggest a great similarity of *R. rolland* to the genus *Tachybaptus*. However, it may have resulted from the scarcity of specimens examined. Although the two species of *Rollandia* are far from each other in the morphospace (PCA), they are linked by the minimum-spanning tree. Such results are most probably due to the fact that *R. micropter*a was the only flightless species included in PCA. Flightlessness results in many adaptations (LIVEZEY 1989), which are reflected in dimensions of the body, including the height of the crista sterni (which was used for calculating the "body size" factor). Thus, if the data from the literature and those obtained in the present study are taken into account it seems that the two species should be maintained in the genus *Rollandia*.

2. *Tachybaptus*

The four taxa of the genus *Tachybaptus* examined show a high level of similarity in the number of characters shared as well as in the results of the cluster analysis and PCA. Thus, the present results strongly support the opinion that these taxa (including *T. dominicus*) belong in one genus (FJELDSÅ 1977, 1985b, 1988; STORER 1976, 1979; VLUG & FJELDSÅ 1990). In the twentieth century, several attempts have been made to change the systematic position of *T. dominicus*. Some authors place it in *Poliocephalus* (e. g. PETERS 1931; SANDERS 1967), others in Podiceps (HOWARD & MOORE 1991; SIMMONS 1962), *Tachybaptus* (e. g. FJELDSÅ 1977, 1985b, 1988; DEL HOYO et al. 1992; STORER 1967c, 1979; VLUG & FJELDSÅ 1990) or even in the separate genus *Lymnodytes* (SIMMONS 1979, 1985). Placing this species in *Tachybaptus*, FJELDSÅ (1977, 1985b, 1988) admits that it differs in some respect from the remaining species of the genus. In consequence, he suggests that *T. dominicus* diverged earlier than its congeners from the phylogenetic tree. The present results (especially the number of characters shared with the members of the other genera) accord with this theory, since *T. dominicus* has approximately as many characters in common with the genus *Tachybaptus* as with *Rollandia*, which is supposed to be ancestral to most other grebes (FJELDSÅ 1985a, 1985b).

3. *Podilymbus*

The genus *Podilymbus* is placed together with *Rollandia* and *Tachybaptus* in the tribe *Podilymbini* (STORER 1963a). Its relationship with *Tachybaptus* was confirmed by the patterns of the downy young (STORER 1967a) and the number of the fused dorsal vertebrae (SANDERS 1967). Two species which form this genus are closely related to each other and clearly separated from the other grebes (SANDERS 1967; STORER 1976; ZUSI & STORER 1969), which was shown in the phylogenetic tree (e. g. FJELDSÅ 1977, 1985b). The present results fully agree with the data mentioned above, confirming the distinctness of the genus and its relationships with *Tachybaptus* (osteological evidence and PCA) and *Rollandia* (osteological evidence).

4. *Poliocephalus*

On the basis of ethological, morphological and anatomical evidence, it is believed that the genus *Poliocephalus* has no close relatives (STORER 1971, 1987). Its relation with the genus *Rollandia* was suggested by FJELDSÅ (1983b) and STORER (1987), and with "*P.*" *major* by FJELDSÅ (1983b). According to STORER (1976), the species differs markedly from the genus *Podiceps*, with which it may be considered convergent. Although the present results are based on scarce data, they generally agree with the data from the literature, suggesting the distinctness of the genus as well as its distant relationships with *Rollandia* (osteological evidence), *Podiceps* (osteological evidence, PCA) and *Tachybaptus* (cluster analysis and PCA).

5. "*Podiceps*" *major*

There has been much doubt about the systematic position of "*Podiceps*" *major* since WETMORE & PARKES (1954) transferred it from the genus *Aechmophorus* to the genus *Colymbus*. The generic name *Colymbus* LINNAEUS, 1758, has been suppressed in favour of *Podiceps* LATHAM, 1787 by the International Commission on Zoological Nomenclature (Opin. 401, 1956, Opin. Decl. Rend., 13, p.4). "*P.*" *major* differs from the other species of *Podiceps* in many vital, behavioural, morphological and anatomical characters (e. g. FJELDSÅ 1983b; GREENQUIST 1982; SANDERS 1967; STORER 1963a, 1963b, 1967a). Some authors place it together with the type species *P. grisegena* in a new genus, *Pedetaithya* (KAUP 1829), subgenus *Pedetaithya* (WOLTERS 1975) or a "species group" within the genus *Podiceps* (SIMMONS 1962). Although the present results indicate that "*P.*" *major* is more similar to *P. cristatus* and *P. grisegena* than to the smaller *Podiceps* species, they definitely do not confirm such great similarity and relationship between "*P.*" *major* and *P. grisegena*. STORER'S (1963b) conclusion that "*P.*" *major* >>... may be more closely related to the large species of *Podiceps* than to *Aechmophorus* but it is not very close to either<<, was later supported by other studies (e. g. SANDERS 1967; STORER 1967a). According to FJELDSÅ (1981, 1983b), the species may have diverged from the phylogenetic tree close to *Poliocephalus*, and so it is the lowest branch of the *Podiceps*/*Aechmophorus* complex. This assumption is presented in several papers showing the phylogenetic tree of grebes (FJELDSÅ 1977, 1982b, 1985b, 1988). The present results do not confirm the similarity of "*P.*" *major* and the genus *Poliocephalus*; the osteological evidence as well as cluster analysis and PCA, indicate that "*P.*" *major* is not closely related to any genus hitherto known. However, it may have diverged early from the phylogenetic tree, as suggested by FJELDSÅ. Although they are not close to "*P.*" *major*, the genera *Podiceps* and *Aechmophorus* are the most similar to it. Therefore, it seems reasonable to place the species in a genus by itself. This conclusion has already been reached by FJELDSÅ (1982b) and SANDERS (1967), while STORER (1979) and DEL HOYO et al. (1992) claim that it probably represents a distinct subgenus. However, none of the authors suggested any name. Therefore, it is proposed here to create a new monotypic genus for the species "*P.*" *major* (BODDAERT, 1783).

Podicephorus genus nov.

Colymbus LINNAEUS, 1767, Systema Naturae, Vol. 1, p. 220. Type: *Colymbus arcticus* LINNAEUS.

Podiceps LATHAM, 1787, General Synop. Birds, Suppl., p. 294, syn. nov. (partim). Type: *Colymbus cristatus* LINNAEUS.

Pedetaithya KAUP, 1829, Skizzirte Entwicklungsgeschichte u. natürliches system der Europäischen Thierwelt. Darmst. et Leipz., p. 44. Type: *Colymbus griseigena* (sic !) BODDAERT.

Pedeaithyia (pro *Pedetaithya* KAUP, 1829) GRAY, 1842, App. List Gen. Birds, 15.

Podeaithyia (pro *Pedetaithya* KAUP, 1829) GRAY, [1846], Gen. Birds, 3, 1849, 632, 633.

Pedetaethyia (emend. pro *Pedetaithya* KAUP, 1829) AGASSIZ, 1846, Nomen. Zool. Index Univ.

Pedetaithyia (pro *Pedetaithya* KAUP, 1829) REICHENBACH, [1852], Av. Syst., iii.

Podoaithyia (pro Pedetaithya KAUP, 1829) GIEBEL, [1876], Thesaur. Orn., 3, 1877, 248.

Aechmophorus COUES, 1862; Proc. Acad. Nat. Sci. Philadelphia, p. 229, (partim). Type: *Podiceps occidentalis* LAWRENCE.

Description. Presence of a canal in the hypotarsus for the tendon of M. flexor perforatus digiti II. Presence of 4 fused and 2 unfused dorsal vertebrae. Muscle characters: between *Podilymbus* and *Podiceps*, but closer to the *Podiceps* group. Distal head of M. extensor longus digiti III present. Pattern of downy young: bare crown patch (rest of plumage outside the range of variation of the *Podiceps* sensu stricto). Platform behaviour of the *Podiceps*-type. Courtship behaviour: lack of Penguin Display and Discovery Ceremony; Nodding and Turning Ceremony present. Differs from the other genera in its combination of osteological characters and proportions of body size (PCA and cluster analysis).

Type species of *Podicephorus* gen. nov.: *Colymbus major* BODDAERT, 1783; by present designation:

Podicephorus major (BODDAERT, 1783) comb. nov.

Colymbus major BODDAERT, 1783, Table Planches Enlum., p. 24; – WETMORE & PARKES, 1954, J. Washington Acad. Sci., 44: 126–127.

Colymbus cayennensis GMELIN, 1790, Syst. Nat. (2) p. 293.

Colymbus bicornis LICHTENSTEIN, 1823, Verz. Doubl. Zool. Mus. Berlin, p. 88.

Colymbus Salvadori STEJNEGER, 1885, Bull. U. S. Nat. Mus. 29, p. 13.

Podiceps cayanus LATHAM, 1790, Ind. Orn., 2, p. 781.

Podiceps leucopterus KING, 1828, Zool. Jour., 4, No 13, p. 101.

Podiceps chilensis FRASER, 1843, Proc. Zool. Soc. London, 11, p. 119.

Podiceps major: GRAY, 1846, Gen. Birds, III, p. 633; – TACZANOWSKI, 1879, Proc. Zool. Soc., London, p. 244.

Podiceps bicornis BIBRA, 1853, Denk. Math.-Naturw. Kl. Akad. Wiss., Wien, p. 132.

Podiceps (*Pedetaithya*) *major*: WOLTERS 1975, Die Vogelarten der Erde, Lief. I, p. 16.

Aechmophorus major: SCLATER & SALVIN 1873, Nomenclator Avium Neotropicum, p. 150.

Remarks. Synonyms and citations after AGASSIZ (1852), DOMANIEWSKI (1930), HELLMAYR & CONOVER (1948), NEAVE (1940), SHERBORN (1928), STORER (1979), TACZANOWSKI (1886), VLUG & FJELDSà (1990) and WOLTERS (1975).

The new generic name depicts distant similarities of the genus to *Podiceps* and *Aechmophorus*. Judging from the behavioural and morphological evidence, *Podicephorus major* is closer to the *Poliocephalus-Podiceps-Aechmophorus* complex than to any other genera (e. g. FJELDSà 1983b; STORER 1967a; present data). On the other hand, its hypotarsal character does not agree with the tribe *Podicipedini* sensu STORER (1963a), to which the genera *Podiceps* and *Aechmophorus* belong. This would support SANDERS's (1967) opinion that the division of *Podicipedidae* into two tribes (*Podilymbini* and *Podicipedini*) should be discarded. Alternatively, the division could remain but it should be based rather on a combination of characters than on the presence/absence of an extra canal in the hypotarsus. At least one character (Skull: 4, Fig. 6) is unique in *Podicephorus major*; probably more such characters could be described if more specimens were examined.

6. *Podiceps*

Based on the anatomical and ethological evidences, the genus *Podiceps* (excluding "*P*." *major*) may be divided into two, closely related groups: *auritus*, *grisegena* and *cristatus* versus *nigricollis*, *gallardoi*, *taczanowskii* and *occipitalis* (FJELDSÅ 1977, 1982b, 1988; STORER 1969). One part of the present results (number of common characters) fully supports the division. On the other hand, the results of the cluster analysis and those of PCA suggest that *P. auritus* belongs in the other group. This does not agree with FJELDSÅ (1973b) and STORER's (1969) opinion that the closest relative of *P. auritus* is *P. grisegena*. Since this last assumption is based on many various ethological and morphological characters, and is supported by the present osteological evidence, it seems that in this case the results of the cluster analysis and PCA should not be taken at face value.

The skeletal elements of two subspecies of *P. auritus* (*auritus* and *arcticus*) studied by FJELDSÅ (1973a, 1973c) seem to differ only in size. The results of the cluster analysis and PCA indicate that the two forms are very close to each other.

Although according to many handbooks (e. g. KUROTCHKIN 1985; PALMER 1962; WITHERBY et al. 1949) the two subspecies of *P. grisegena* (*grisegena* and *holboellii*) are separated only by their measurements, the present paper indicates that this is not the case. Apart from the absolute size differences (which according to PALMER (1962) may reach the level of no overlap), *P. g. holboellii* (in contrast to *P. g. grisegena*) shows great sexual dimorphism in the size of all skeletal elements. Moreover, these two subspecies also differ in proportions of their bodies, which is clearly visible in the results of principal component analysis. Here, the distance between them is much greater than the distance between the two subspecies of *P. auritus*. *Podiceps g. grisegena* and *P. g. holboellii* share only 40 out of the 55 characters described, which seems to be a rather low figure for specimens of the same species. Finally, the two forms also differ in colour (FJELDSÅ 1973a). Since the differences are surprisingly big, the distribution areas do not overlap and, consequently, the forms probably do not interbreed; it seems reasonable to restore *P. g. holboellii* to its former species status, with a spelling correction in the species name:

Podiceps holboellii REINHARDT, 1854

Podiceps Holböllii REINHARDT, 1854; Vidensk. Meddelelser Naturhist. Forening, Copenhagen, (1853), p. 76.

Podiceps cooperi LAWRENCE, 1858, in BAIRD: Rep. Expl. Surv. R. R. Pacific 9, p. 893.

Colymbus holboellii BENT, 1919, Bull. U. S. Nat. Mus. 107, p. 9.

Its closest relative, as indicated by the osteological evidence, cluster analysis and principal component analysis, is *P. g. grisegena*, which should also be restored to its species status:

Podiceps grisegena (BODDAERT, 1783)

Colymbus grisegena BODDAERT, 1783, Table Planches Enlum., p. 55.

Podiceps griseigena (sic !) DEGLAND et GERBE, 1867, Orn. Eur. II. Ed. II. p. 579.

Remarks: Synonyms after NAUMANN (1903), HELLMAYR and CANOVER (1948) and STORER (1979).

7. *Aechmophorus*

The present results indicate the distinctness of *Aechmophorus occidentalis* and its affinity with the genus *Podiceps* and the species *Podicephorus major*. These conclusions are similar to those reached by SANDERS (1967) and STORER (1963a, 1967a, 1969) and shown in the phylogenetic tree by FJELDSÅ (e. g. 1985b, 1988).

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